PHENOTYPIC CHARACTERIZATION OF LOCAL CHICKEN ECOTYPES IN WESTERN ZONE OF TIGRAY, NORTHERN ETHIOPIA

MSc. THESIS

By

SHISHAY MARKOS

FEBRUARY, 2014

JIMMA, ETHIOPIA

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BY
SHISHAY MARKOS

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APPROVAL SHEET

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

As thesis research advisors, we have here by certified that we have read and evaluated this thesis prepared, under our guidance, by Shishay Markos entitled “Phenotypic characterization of local chicken ecotypes in Western Zone of Tigray, Northern Ethiopia.” We recommend that it to be accept as fulfilling the thesis requirement**.**

Dr. Berhanu Belay (PhD) __________________ ________________
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Co- Advisor Signature Date

As members of the Board of examiners of the final M.Sc. Thesis Open Defense examination, we certify that we have read, evaluated the thesis prepared by Shishay Markos and examined the candidate. We recommend the thesis could be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Agriculture (Animal Breeding and Genetics).

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External Examiner Signature Date

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Internal Examiner Signature Date

DEDICATION

I dedicate this thesis manuscript to my late mother for her valuable advice to shape me and to be successful in my life.

STATEMENT OF THE AUTHOR

I hereby declare this thesis is my own work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in advanced (MSc.) degree only at the Jimma University and is deposited at the University Library to make available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institutions anywhere else for award of any academic degree, diploma or certificate.

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Name: Shishay Markos Signature________________

Place: Jimma University, Jimma

Date of submission__________________________

BIOGRAPHICAL SKETCH

The author, Shishay Markos was born on December 1983 in a small village called 'Maygaga' which is located in the outskirt of Adwa Town, Tigray, Ethiopia. He attended his Primary education in Wengelawit Elementary School from 1991 to 1995 and then joined Nigisti Saba Adwa Secondary School from 1996 to 2001 to attend his secondary education.

In the year 2001/2002, Mr. Shishay Markos joined the department of Animal Production and Range Science in the regular program of Awassa College of Agriculture of Debub University and graduated with B.Sc. degree in the field of Animal Production and Rangeland Management in July 2005.

Upon his graduation, he was employed as expert at Tselemti Wereda office of Agriculture and Rural Development of Tigray Bureau of Agriculture and Rural Development and had worked as Animal science expert from August 01/09/2005 - 09/11/2007.

On December 2007, he was recruited as junior researcher at Humera Agricultural Research Center (HuARC) of Tigray Agricultural Research Institute (TARI). After five year service at the research center; he joined Jimma University in September 2012 to pursue his post – graduate study to M.Sc. Degree in Animal Breeding and Genetics.

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ABBREVATIONS AND ACRONYMS

ALRC	Andassa Livestock Research Center
AnGRs	Animal Genetic Resources
ASCC	Average Squared Canonical Correlation
BONEPWA	Botswana Network of People Living with HIV/AIDS
Cm	Centimeter
CSA	Central Statics Agency
DZARC	Debrezeit Agricultural Research Center
EEA	Ethiopian Economic Association
FAO	Food and Agriculture Organization
Gm	Gram
HuARC	Humera Agricultural Research Center
ILRI	International Livestock Research Institute
Kg	Kilogram
Km	Kilometer
MASL	Meter Above Sea Level
Mm	Millimeter
NA	Not Available
NAMP	North American Meat Processors Association
RIR	Rhode Island Red
RSHD	Rural Self-Help Development Association
SIDA	Swedish International Development Cooperation Agency
SNNPR	Southern Nations, Nationalities and People Region
TARI	Tigray Agricultural Research Institute
USDA	The United States Department of Agriculture
Wks	Weeks

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ABSTRACT

The study aimed to characterize local chicken ecotypes in terms of phenotype in Western Zone of Tigray. Multi-stage sampling procedures were employed to select sample kebeles and respondents. Administration of pretested questionnaire and measurement of morphometric traits from 770 local chickens were employed. Qualitatitive traits of 1642 local chickens were observed and recorded. Forty eight matured local chickens of both sexes were used for carcass trait evaluation. Functional traits were studied through monitoring of randomly selected chicken owners and structured questionnaire. Qualitative chicken traits and qualitative data of the survey were analyzed using descriptive statistics of SPSS 16. Kruskal-Wall's test option of Non-parametric tests of SPSS 16 was employed to test proportion difference of each variable among the agro-ecologies. Quantitative, carcass and performances traits among the three agro-ecologies were analyzed by general linear model of SAS 2008 and Tukey mean comparison was employed for significantly different traits among agro-ecological zones. Multivariate analysis of principal component analysis, canonical discriminant analysis, step wise discriminant and cluster analysis using 21-quantitative traits were performed by SAS 2008 for males and females chicken ecotypes separately. The overall mean live weight of matured male and female chicken was 1.569±0.004kg and 1.261±0.004 kg, respectively. The overall mean dressing percentage of local male and female chickens was 66.82±0.3 and 63.43±0.03 respectively. The average age of sexual maturity of local male and female chickens was 5.71±0.03 and 7.19 ±0.04 months, respectively. The overall hatchability of eggs was 74.37±0.57 %. Red (51.2%), Gebsima (18.2%) and Anbesima (8.9%) were the most frequent dominant plumage colors in the study area. Disease (1st) and predators (2nd) were the major village chicken production constraints. On the other hand, market and feed access were the two pronounced opportunities of village chicken production. Earlobe length, wingspan, skull length and shank length were most important traits for discriminating among female chicken ecotypes while wingspan, neck length, earlobe length, spur length, body length and shank length were most important discriminatory traits among male chicken ecotypes.97.3% of female and 100% male chicken ecotypes were correctly classified with error rate of 2.7% and 0%,respectively.Based on GLM analysis, morphological variations, multivariate analysis and focused discussion groups, the local chicken ecotypes of western Tigray classified as lowland, midland and highland chicken ecotypes. Plumage color (1st), egg laid/clutch (2nd) and comb type (3rd) were the most preferred attributes used for selection breeding chicken. Egg laid/clutch (1st), body weight/growth (2nd) and adaptations (3rd) were most preferred traits to be improved through breeding. Agro-ecologically friendly and community based genetic improvement programmes should be designed and implemented with incorporation of breeding objectives, trait preference and adaptive genetic merits of local chickens for conservation and sustainable utilization of the diverse indigenous chicken genetic resources.

Key words: Multivariate analysis, Phenotypic characteristics, Breeding objectives, Trait preference

1. INTRODUCTION

Chicken (*Gallus gallus domesticus,* 2n=78) is a domesticated fowl, a subspecies of the Red Jungle fowl. It is one of the most common and widespread domestic animals throughout the globe. Domestic chicken is the first populous livestock species with an estimate of 19 billion, three per person in the world (The Economist, 2011). Poultry contributes about 30% (Permin & Pedersen, 2000) of all animal protein consumed in the world. Moreover, they share 34.6% of global livestock meat, of which chicken species account 88% of the global poultry meat and 30.1% of global animal meat (FAO, 2012a). Village poultry make a significant contribution to poverty alleviation and household food security in many developing countries (Alders & Pym, 2009). About 1.5 billion chickens are raised in Africa, 80% of them belonging to local chicken populations and found in the rural and peri-urban areas, where birds are raised in small numbers by the traditional extensive or semi-intensive, low-input–low-output systems (Sonaiya, 1997; Gueye, 1998). Indigenous chickens have significant contribution to food security and economic sustainability of rural households (Gueye, 2002; Aboe *et al*., 2006; Faustin *et al.*, 2010).

Chickens are the easiest livestock species to raise for sale and home consumption, providing high quality protein and micronutrients, which play an important role in the health and nutrition of several million people in developing countries, especially those below poverty line .Because they require less space, they are less capital intensive and easy to manage as they can be reared with in or near homesteads. Village poultry are available asset to local populations throughout Africa and they contribute to food security, poverty alleviation and promote gender equality, especially in the disadvantaged groups (HIV and AIDS infected and affected people, women, poor farmers, etc) and less favored areas of rural Africa where the majority of the poor people reside **(**RSHD, 2011).

The impact of village chicken in the national economy of developing countries and its role in improving the nutritional status, income, food security and livelihood of many smallholders is significant owing to its low cost of production (Abdelqader *et al*., 2007)**.**

On top of these merits, village poultry can provide the start of the owner climbing the “livestock ladders’’ leading to other livestock species such as goats and cattle or serve as “transport (transitional) bridge” from small livestock to large livestock species production (Dolberg, 2003)**.**

Moreover, village chickens are well known to possess desirable characters/special features such as ideal mothers, good sitters, hatch their own eggs, thermo tolerant, excellent foragers and ability to utilize the limited and poor quality feed resources, immunities to resist common poultry diseases, the special meat and egg quality/flavor, hard eggshells, high fertility and hatchability as well as high dressing percentage. The local chickens are of great importance as the farmers may little or not add any inputs (concentrate feeds & incubators) like for raising exotic breeds (Aberra, 2000; Amsalu, 2003). However, regardless of the above desirable characters, they have been neglected in areas of scientific research on its characterization, performance potential, and development efforts particularly in remote areas of Ethiopia. In addition, rearing them has been considered as a sideline agricultural activity.

Recent poultry population of Ethiopia is estimated to be about 51.35 million with indigenous chicken of non-descriptive breeds accounting 96.83%, hybrid chicken contributing 2.37% and exotic breeds of 0.8% (CSA, 2013). Moreover, 97.3% of indigenous chickens have been distributed in different agro-ecological zones of Ethiopia (CSA, 2011) and kept under a traditional family-based scavenging management system (Alemu & Tadelle, 1997). This wide spread distribution of indigenous chickens indicates their adaptive potential to different environmental conditions, diseases and other stresses (Halima, 2007). Likewise, Aberra, (2000) reported that indigenous chickens have been reared in different village poultry production system and this enables them to develop desirable characters such as thermo tolerant, resistant to some disease, good egg and meat flavor, hard eggshells and high dressing percentage. Furthermore, they are also characterized by fast generation interval and high reproductive rate as they are prolific, easy to rear and their output can be generally expanded more rapidly and easily than that of other livestock (Duguma, 2009).

Fisseha *et al*. (2010) reported that the total national chicken egg and meat in Ethiopia is estimated to be about 78,000 and 72,300 metric tons, respectively and more than 90% of the national chicken egg and meat is obtained from indigenous chickens (Nigussie, 2011). Moreover, the average annual egg production of indigenous chicken is estimated to be 60 egg/hen (Fisseha *et al.*, 2010). Similarly, Mekonnen (2007) reported that the live weight of indigenous chicken is about 1.6 kg and 1.3 kg for male and female respectively at six month of age. Efforts to improve the performance of indigenous chickens have been launched by Ethiopian government through introduction of exotic breeds since the early 1990 (Pagani & Abebe, 2008).This indiscriminate introduction of exotic genetic resources before proper characterization, utilization and conservation of indigenous genetic resources is the main cause of the loss of indigenous chicken genetic resources (Halima, 2007).

This calls for characterization of indigenous chickens in their production system to pave the way for designing breeding programs and explores the variability. Characterization is the distillation of all knowledge which contributes to the reliable prediction of genetic performance of an AnGR in a defined environment and provides basis for distinguishing between different AnGRs and baseline information for selecting and designing of breeding strategies for improving genetic potential of the available Ethiopian indigenous chicken breeds so as to boost their productivity (FAO, 2012b). Characterization is the initial step for long-term genetic improvement as it provides the basis for any other livestock development interventions and pre-requisite information for designing appropriate breeding and utilization programs (Johann Solkner *et al.*, 2009). Genetic characterization is most accurate method to evaluate genetic diversity but needs high technology and cost (Romanov & Weigend, 2001). Phenotypic characterization based on large sample size provides a reasonable representation of overall genetic performance (Humphrey, 1991).

Several scholars have done different researches on indigenous chickens of Ethiopia for enhancing sustainable poultry productivity through characterization of genetic variation among genotypes and their production environments. For instance, research on phenotypic and genetic characterization of indigenous chicken ecotypes had been done in some selected areas of Ethiopia (Tadelle, 2003) and in Northwest Ethiopia (Amhara region) (Halima, 2007).

Nigussie *et al*. (2010a) and Nigussie (2011) examined on morphological and genetic characterization of indigenous chickens in Horro, Farta, Konso, Mandura and Sheka districts of Ethiopia.

Phenotypic characterization of indigenous chickens of Ethiopia have been also carried out at DZARC (Duguma, 2006), at Fogera district (Bogale, 2008), at North Wollo zone of Amhara regional state **(**Addisu, 2012) and at Southern Tigray (Hailemicael, 2013). Moreover, Characterization of Smallholder poultry production and market system had been also carried out in three districts of SNNPRs (Mekonnen, 2007), in Gomma wereda of Jimma zone (Meseret, 2010), Gondar town (Wondu *et al.*, 2013) and in Bure wereda (Fisseha, 2009). Dawit (2010) had also done market chain analysis of poultry in Alamata and Atsbi-Wonberta Woreda of Tigray region .No or little work has been done to characterize the existing local chickens in Tigray region and particularly in western zone of Tigray. Appropriate design of breeding programs is impossible for local chicken ecotypes that have not been adequately characterized either phenotypically and /or genetically. Thus, this research project was designed to contribute in filling the gap and set with the following objectives.

General Objective

- To characterize local chicken ecotypes based on phenotypes in western zone of Tigray

Specific Objectives

- To characterize local chickens in terms of physical, functional, and adaptive traits in their Production system
- To assess farmers' trait preference and breeding objectives of local chickens in the study area
- To estimate carcass characteristics and
- To assess the chicken production constraints and opportunities.

Hypothesis of the study

- ✓ There is a variability in phenotypic characters among the local chicken ecotypes raised in low land, midland and highland areas of western zone of Tigray

2. LITERATURE REVIEW

2.1. Origin and Domestication of Chicken

Domestic chicken belongs to the genus *Gallus* that comprises the four wild species of jungle fowls: red jungle fowl (*Gallus gallus*), grey jungle fowl (*G. sonneratii*), Ceylon jungle fowl (*G. lafayetii*) and green jungle fowl (*G. varius*) (Crawford, 1990).

The geographical origin and ancestry of the domestic chicken have been an issue of debate since Darwin first proposed the Indian red jungle fowl (*Gallus gallus*) as the single ancestor of all domestic chicken, and thus a monophyletic origin (Darwin, 1868). He based his theory on the marked morphological similarities between the domestic chicken and the red jungle fowl, and the fact that crosses between the two generated fertile offspring, while crosses between domestic chickens and the three other jungle fowl species resulted in low survival of the chicks (Darwin, 1868). Likewise, early molecular genetic studies of mitochondrial DNA (mtDNA) supported the view that the red jungle fowl was the sole ancestor of the domestic chicken (Fumihito *et al.*, 1994,1996).The earliest archeological findings of chicken remains-bones larger than the red jungle fowl—were found in Southeast Asia and were estimated to be almost 8000 years old (West & Zhou, 1988).

Additional archeological findings-bones and art objects depicting chickens in the Indus Valley dated to about 2500B.C.-suggested that there have been multiple domestication events of the chicken (Darwin, *1868*). The multiple geographical origin of the chicken is also supported by molecular genetic data that further implies that the majority of European and Middle Eastern domestic chickens originate from India (Liu *et al.*, 2006; Kanginakudru *et al.*, 2008). Further molecular studies present evidence that American, Oceanic and African chickens also originated from India, suggesting that India was the original platform for the worldwide dispersal of chicken (Berthouly-Salazar *et al.*, 2010; Dancause *et al.*, 2011; Muchadeyi *et al.*, 2008).

The evolutionary process of chicken domestication has four distinct stages in the world (Crawford, 1984). The first evolutionary stage was by use of these animals in religious, cultural and traditional purposes which resulted in the selection of color and different morphological features. During the second stage chickens were moved from centers of domestication to other countries, continents, other cultures and other environments. The major forces of genetic changes were genetic drift, migration and natural selection for adoption to new environmental conditions. The third stage was epitomized by the 'hen crazy' of the 19th century. At this stage most of the breeds and varieties known at present were developed. The fourth stage belonged to the 20th century which grew out of the cultural 'hen crazy' into the vast chicken meat and egg industry of today. The industry has been very quick to adopt new advances in genetics and breeding and new advances in technology.

2.2. Local Chicken Population Dynamics of Ethiopia

The total poultry population at national level in 2003, 2009, 2010 and 2013 was estimated to be about 35,656,390 chickens (CSA, 2003/04), 42,053,263 chickens (CSA, 2009/10), 49,286,932 chickens (CSA, 2011) and 51,350,738 chickens (CSA, 2013), respectively. Regionally, Oromia, Amhara, SNNR and Tigray stand first, second, third and fourth rank in chicken population size, respectively, in the four years. With regard to population dynamics, there is an increasing trend in chicken population with 17.74% (6,396,873 chickens) and 17.2 % (7,233,669 chickens) increment from 2003 to 2009 and 2009 to 2010, respectively. Similarly, there is a growth of 4.2 % (2,063,808 chickens) from 2010 to 2013 (Table 1). This could be due to the increase in poultry products and byproducts demand. With respect to breed wise dynamics, 40.6 million (96.61%), 1.19 million (2.84%) and 0.231 million (0.55%) of the total poultry were reported to be indigenous, hybrid and exotic breeds, respectively, in 2009/10. Likewise, it was reported that 47.9 million (97.3%), 1.14 million (2.32%) and 0.188 million (0.38%) of the total national poultry were indigenous, hybrid and exotic breeds, respectively in 2010 (CSA, 2011). 96.83 % (49.72 million), 2.37% (1.22 million) and 0.8% (0.411 million) of the total poultry are reported to be indigenous, hybrid and exotic chickens, respectively (CSA, 2013).

With reference to national poultry flock structures, poultry comprises of cocks, cockerels, pullets, non-laying hens, chicks and laying hens. Most of the poultry are chicks (36.44%), and followed by laying hens (33.5%), cocks (11.38%) , pullets (9.76%), cockerels (5.45%) and non-laying hens (3.47%) in the year of 2009 (CSA, 2009/10). In consistent to this, majority of the total poultry are chicks (37.12%), followed by laying hens (32.25%), cocks (5.6 million), pullets (4.9 million), cockerels (2.8 million) and non-laying hens (1.83 million) in the year of 2010 (CSA, 2010/2011).

Similarly, most of the total poultry populations are chicks (38.3%), followed by laying hens (33.37%). Pullets are estimated to be about 5.04 million in the country. Cocks and cockerels are also estimated separately, and are about 5.26 million and 2.72 million, respectively. The others are non-laying hens that make up about 3.01 percent (1.55 million) of the total poultry population in the country (CSA, 2013).

Table 1: Regional and national chicken population dynamics and distribution in Ethiopia (000)

Regional	Years												
	2003/04	2009/10				2010/11				2013/2014			
	Total	Local	hybrid	Exotic	Total	local	Hybrid	Exotic	Total	Local	Hybrid	Exotic	Total
Tigray	3725.11	3867.84	331.40	66.83	4,266.08	3998.45	281.97	28.17	4308.60	4717.7	371.2	198.9	5287.80
Afar	49.29	26.51	-	-	29.37	66.28	-	-	67.32	112.02	-	-	124.49
Amhara	11243.77	12297.02	334.73	107.87	12,739.62	13587.40	389.89	71.20	14048.49	14085.1	368.4	71.34	14524.8
Oromia	12761.34	14880.25	436.70	19.98	15,336.94	18347.47	376.39	38.42	18762.28	18870.9	362.3	80.68	19313.9
Somalia	173.19	55.75	-	-	55.75	105.97	-	-	106.11	196.3	-	-	196.40
B.Gumuz	785.36	819.16	-	-	820.99	1144.15	3.87		1149.07	1036.0	-	-	1041.56
SNNR	6779.90	8386.52	83.44	33.607	8503.564	10276.08	86.759	44.97	10407.81	10217.8	105.5	30.57	10353.8
Gambella	NA	209.20	NA	NA	210.33	302.80	-	-	303.02	342.4	1.28	-	344.04
Harari	31.59	37.82	1.07	0.30	39.19	52.33	2.02	-	53.28	71.20	-	-	71.70
A. Ababa	62.36	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D.Dawa	44.48	47.51	2.24	-	51.43	74.06	2.83	4.08	80.96	74.30	3.60	-	92.28
Total	35,656.39	40627.57	1194.21	231.48	42,053.26	47954.98	1143.92	188.03	49,286.93	49723.6	1215.3	411.81	51350.7
Comp (%)	100%	96.61%	2.84%	0.55%	100%	97.3%	2.32%	0.38%	100%	96.83%	2.37%	0.8%	100%

Source: CSA (2003/04¸ 2009/10, 2010/11 and 2013/14)

NA= Not available

Table 2: Flock composition of poultry population in Tigray region and in Ethiopia (000)

Year	breed	Cocks	Cockerels	Pullets	Non-laying hens	Chicks	Laying hens	All
2009/10								
Ethiopia	Local	4602.2(10.9%)	2221.2 (5.3%)	3960.7 (9.4%)	1418.0 (3.4%)	14967.3(35.6%)	13458.2 (32%)	40627.6 (96.6%)
	Exotic	42.6 (0.1%)	11.9 (0.03%)	36.4 (0.09%)	7.9 (0.02%)	16.6 (0.04%)	116.2 (0.28%)	231.5 (0.55%)
	Hybrid	141.9 (0.34%)	58.3 (0.14%)	108.8 (0.26%)	34.0 (0.08%)	339.1 (0.81%)	512.1(1.22%)	1194.2 (2.84%)
Tigray	local	358.3 (8.4%)	314.7 (7.4%)	448.2 (10.5%)	211.6 (5.0%)	1492.7 (35.0%)	1042.3 (24.4%)	3867.8 (90.7%)
	Hybrid	31.3 (0.73%)	18.9 (0.44%)	31.1 (0.73%)	13.4 (0.31%)	119.4 (2.8%)	117.3 (2.75%)	331.4 (7.76%)
	Exotic	4.4 (0.10%)	-	5.6 (0.13%)	-	-	53.1 (1.24%)	66.8 (1.57%)
2010/11								
Ethiopia	local	5,453.3(11.1%)	2,693.9(5.5%)	4,728.0(9.6%)	1,780.1(3.6%)	17,927.3(36.4%)	15,372.4(31.2%)	47,955.0 (97.3%)
	Hybrid	122.8 (0.25%)	68.9 (0.14%)	126.1(0.26%)	43.2 (0.09%)	352.0 (0.71%)	430.9(0.87%)	1,143.9 (2.32%)
	Exotic	38.6 (0.08%)	8.4 (0.02%)	24.1 (0.05%)	11.4 (0.02%)	15.6 (0.03%)	90.0 (0.18%)	188.0 (0.38%)
Tigray	local	402.5(9.34%)	278.2(6.46%)	429.8(9.97%)	215.7(5.0%)	1,569.6(36.4%)	1,102.7(25.6%)	3,998.5 (92.8%)
	Hybrid	28.57 (0.66%)	16.37(0.38%)	33.86 (0.79%)	16.51 (0.38%)	94.28(2.19%)	92.38 (2.14%)	281.97(6.54%)
	Exotic	3.78 (0.09%)	-	1.53(0.04%)	-	-	16.99 (0.39%)	28.2 (0.66%)
2013/14								
Ethiopia	local	5074.4 (9.9%)	2644.1(5.2%)	4859.3(9.5%)	1489.8(2.9%)	19236.4(37.5%)	16419.5(32%)	49723.6 (96.83%)
	Hybrid	131.6(0.26%)	57.95(0.11%)	129.6(0.25%)	42.82(0.08%)	354.1(0.69%)	499.2(0.97%)	1215.3 (2.37%)
	Exotic	54.58 (0.11%)	14.22 (0.03%)	57.39 (0.11%)	15.20(0.03%)	77.6 (0.15%)	192.85(0.38%)	411.81(0.8%)
Tigray	local	419.8(7.94%)	370.5(7.01%)	610.3(11.5%)	220.6 (4.2%)	1718.5 (32.5%)	1378.2(26.1%)	4717.7 (89.2%)
	Hybrid	42.12 (0.8%)	21.9 (0.414%)	45.9(0.87%)	-	127.9 (2.42%)	111.3(2.10%)	371.2 (7.02%)
	Exotic	27.8 (0.53%)	3.78 (0.07%)	23.41(0.44%)	7.50(0.14%)	60.9(1.15%)	75.60 (1.43%)	198.90 (3.76%)

Source (CSA, 2009/10, 2010/11 and 2013/14)

Table 3: Flock composition of poultry population in Tigray region by breed and zone (000) in 2013/14

area	breed	Cocks	Cockerels	Pullets	Non-laying hens	Chicks	Laying hens	All
Tigray	Local	419.72	370.46	610.33	220.57	1718.47	1378.17	4717.72
	Hybrid	42.12	21.87	45.87	7.958	127.88	111.28	371.17
	Exotic	27.77	3.78	23.41	7.50	60.87	75.58	198.90
	Total	489.61	396.11	679.60	250.22	1907.22	1565.03	5287.79
North west Tigray	Local	124.31	169.25	216.34	77.48	604.19	380.71	1572.28
	Hybrid	7.83	-	12.54	-	29.31	20.34	75.62
	Exotic	-	-	-	-	-	-	-
	Total	133.92	173.06	229.18	79.85	633.82	407.04	1656.86
Centeral Tigray	Local	109.91	66.57	141.31	58.23	447.01	349.84	1172.87
	Hybrid	15.13	6.47	17.98	4.17	48.56	51.41	143.72
	Exotic	9.941	-	-	2.464	-	25.99	60.921
	Total	134.98	73.04	165.81	64.86	511.58	427.24	1377.51
Eastern Tigray	Local	68.45	42.32	82.90	31.43	193.24	279.62	697.95
	Hybrid	11.91	5.88	6.68	3.79	30.29	20.27	78.82
	Exotic	5.041	-	9.075	-	-	23.015	79.544
	Total	85.40	50.76	98.65	37.83	260.78	322.91	856.31
Southern Tigray	Local	71.21	44.10	86.09	26.54	228.35	221.76	678.04
	Hybrid	5.23	5.13	6.43	-	11.41	16.60	56.59
	Exotic	9.754	-	7.419	-	-	18.891	45.160
	Total	86.19	50.24	99.93	40.00	246.01	257.25	779.63
Western Tigray	Local	45.85	48.22	83.69	26.89	245.70	146.24	596.58
	Hybrid	2.019	-	2.24	-	8.30	-	16.59
	Exotic	1.26	-	-	-	-	1.699	4.305
	Total	49.12	49.01	86.04	27.67	255.03	150.60	617.47

Source (CSA, 2013/14)

2.3. Merits of Indigenous Chicken Ecotypes

The merits of village chicken production have been documented by different scholars. For example, Gueye (1998) outlined some advantages of indigenous chickens such as the special meat and egg quality/flavor, hard egg shell, high dressing percentages and especially with little special care required for production .The local chicken always fetches better price than exotics because of its taste and flavor.

Although the indigenous chickens are relatively low producers than the commercial breeds, they are more adapted to the environmental challenges and prevailing management levels practiced by smallholder farmers. Village poultry are a valuable asset to local populations as they contribute to food security, poverty alleviation and promote gender equality, especially in the disadvantaged groups (HIV and AIDS infected and affected people, women, poor farmers, etc) and less favoured areas of rural Africa where the majority of the poor people reside (RSHD, 2011).The impact of village chicken in the national economy of developing countries and its role in improving the nutritional status, income, food security and livelihood of many smallholders is significant owing to its low cost of production (Abdelqader *et al*., 2007).

Generally, Village poultry plays a key role in the home economy and its increased production has the potential to improve food security, assist in poverty alleviation and mitigate the adverse economic impacts of HIV/AIDS for rural people (Harun *et al*., 2001). In developing countries nearly all families at the village level, even poor and landless, are owners of poultry where production is feasible and low cost technology is needed to improve production considerably (Upton, 2004). On top of these merits, village poultry can provide the start of the owner climbing the “livestock ladders’’ leading to other livestock species such as goats and cattle or serve as “transport (transitional) bridge” from small livestock to large livestock species production (Dolberg, 2003).

2.4. Local Chicken Ecotypes of Ethiopia

The indigenous chickens of Ethiopia are Non-descriptive breeds with a wide range of morphologic or genetic diversity. Indigenous chickens are found in huge numbers distributed in different agro-ecology categories under traditional family- based scavenging management system (Alemu & Tadelle, 1997). They have various names and are characterized on different basis by different scholars. Teketel (1986) and Bogale (2008) characterized them on the basis of plumage color as *Gebsima* (graish mixture), *Key* (red), *Netch* (white), *Tikur* (black), *Anbesma*, *Seran*, *Libework*, *Netch Teterma*, *Tikur Teterma*, *Key Teterma* and Naked nack (*Angete Melata*). Tadelle (2003) characterized them on the basis of area of geographical origin or market shed name as *chefe*, *horro*, *Jarso*, *Tepi* and *Tilili*. Similarly, Halima (2007) characterized them on basis of market shed name as *Gelila*, *Debre-Elias*, *Melo-Hamusit*, *Gassay*, *Guangua* and *Mecha* and Nigussie (2011) characterized them on similar basis as *farta*, *Konso*, *Mandura* and *Sheka*. Moreover, Addisu (2012) recently characterized the indigenous chicken ecotypes of North Wollo zone as low land, midland and highland ecotypes on the basis of agro-ecology distribution. As a result, there are more than 20 identified and characterized Ethiopian local chicken ecotypes.

2.5. Phenotypic Characterization

Phenotypic characterization of AnGR generally refers to the process of identifying distinct breed populations and describing their external and production characteristics within a given production environment (FAO, 2012b). It should incorporate the population size of the animal genetic resources, its physical description, adaptation, its common uses, social and economic factors such as market orientations, niche marketing opportunities and gender issues, its geographical distribution, prevalent breeding systems, population trends, predominant production systems, description of the natural environment in which it is predominantly found, indicators of performance levels (meat, growth, reproduction, egg) and the genetic distinctiveness of the animal (Weigend & Romanov, 2001). The Ethiopian indigenous chickens are none descriptive breeds closely related to the Jungle fowl and vary in plumage color, comb type, body conformation ,weight (Hailu, 2007) and scavenging management system (Tadelle *et al*., 2003a).

2.5.1. Poultry production systems of Ethiopia

Traditional (village chicken production system) and modern production systems are the two categories of poultry production systems in Ethiopia. Poultry keeping practiced by rural households using family labor is referred as village poultry keeping. This practice is also called rural poultry or rural family poultry or village chicken production system (Aklilu, 2007).

The village chicken productions system is mostly an indigenous integral part of the farming system and comprises the indigenous ecotypes of chickens. They are characterized by short life cycle, quick turn over, small flock size, needs no or less inputs and relatively good outputs levels and accessible at both inter and intra household levels and periodic devastation of the flock by disease and reared in the extensive (scavenging) production systems (Nigussie *et al*., 2010b; Fisseha, 2009; Mammo, 2006). There is no separate poultry house and the chickens live in family dwellings together with human beings. There is no purposeful feeding of chickens and scavenging is almost the only source of diet. There is no designed selection and controlled breeding. It is by natural incubation and brooding that chicks are hatched and raised all over the rural Ethiopia. As a result, it has still remained as a subsistence poultry production system in rural areas.

Modern poultry production consists of the small scale intensive and large scale commercial production systems. The small scale intensive poultry is newly emerging system in urban and peri-urban areas and aimed to produce either broilers or egg type exotic breeds of chicken along commercial lines using relatively modern management methods for income generation in and around major cities and towns such as Debre Ziet. Most of these farms obtain their feeds and foundation stocks from the large scale commercial poultry farms and involved in the supply of table eggs to customers through middlemen. Among several private large scale commercial farms in and in the vicinity of Addis Ababa (majority located in Debre Ziet), ELFORA, Alema and Genesis are the top 3 largest commercial poultry farms with modern production and processing facilities.

2.5.1.1. Flock composition and size

Knowing of flock composition and size of a given livestock breed is a prerequisite for designing, planning and implementation of appropriate breeding strategies and other management interventions. A Study conducted in five agro-ecological regions of Ethiopia revealed that indigenous chickens are the main poultry species in the study villages (Tadelle *et al*., 2003b). They obtained a mean number of breeding females per house hold of 5.4±2 and breeding male to female chicken ratio of 1: 2.5. Similarly, Bogale (2008) reported that the flock size ranged from 1 to 39 chickens with the Cock to hen ratio in Fogera wereda of Amhara regional state was 1:3.2 and with a flock composition of cocks (14.96%), Hens (47.69%), pullet (26.64%) and cockerels (10.71%).

A survey carried out in Northern Gondar of Amhara Regional State in Ethiopia by (Wondu *et al*., 2013) disclosed that the average flock size per household was 10.44 chickens with a range of 2-16 birds and with flock composition of chicks (47.03%), hens (20.21%), cocks (9.5%), pullets (14.75%) and cockerels (8.52%). Previous findings indicated that the average chicken flock size per household was 7.13 in Northwest Ethiopia (Halima, 2007) and 6.2 in Gomma wereda of Jimma Zone (Meseret, 2010). Fisseha *et al*. (2010) also reported that the average chicken flock size per household in Bure, Fogera and Dale weredas was 13.1, 12.4 and 9.22, respectively. Households owned on average of 17±2 chickens with a range of 3 to 45 chicken in Amatola Basin of the Eastern Cape Province of South Africa (Nyoni & Masika, 2012). Halima (2007) reported that chicken flock size per household varies between seasons mainly due to the availability of feed, the occurrence of diseases and the presence of predators as well as the economic status of the owners in Northwest Ethiopia.

2.5.1.2. Ownership pattern and gender role

Chickens are reared by any member of a given family in both urban and rural areas of Ethiopia because they require less input (space, labor, capital, feeds and others). A study conducted in Fogera Woreda of Amhara Regional state (Bogale, 2008) revealed that women had higher responsibility of providing feed and water (59.72%), cleaning chicken house (62.5%), selling chicken (56.95%) and selling eggs (63.89%) while men had the responsibility of shelter construction (63.89%).The same study also indicated that women had higher decision making power in selling eggs (56.94%), selling chickens (55.55%), consuming eggs (54.17%), purchasing of eggs (55.56%) and chickens (51.39%**)** whereas men had greater power in decision making of consuming chickens (51.39%), purchasing drugs (58.32%) and provide as a gift (55.56%). Similarly, Meseret *et al*. (2011) reported that women were highly responsible for provision of water and supplementary feed to chicken (100%), selling of chicken (94%) & cleaning chicken's waste in their night time resting areas (91%) in Gomma wereda of Jimma zone.

In study conducted in Bure Woreda of Amhara regional state by Fisseha (2009) showed that Women had major responsibility in cleaning bird's house (38.6%), feeding birds (80.7%), selling birds (82.9%) and selling eggs (54.6%). However, men were involved mainly on shelter construction (97.5%) & taking sick birds for treatment (89.3%). Similar study conducted in Metema District of Amhara Regional state by **(**Hassen *et al*., 2012) indicated that feeding (73.33%), watering (72%) and house cleaning (69.33%) were practiced by wives while bush clearing around the poultry house is mainly performed by husband. In Uganda, Poultry management activities such as feeding and watering, treatment with herbs and cleaning poultry houses are mainly carried out by women and children while vaccination, treatment with drugs, building poultry houses and marketing poultry are mainly accomplished by men (FAO, 2009a).

2.5.1.3. Feeding and feed resources

Feed is by far one of the main environmental factors that influences the productivity and profitability of poultry production. The most commonly practiced type of Village poultry production system in Ethiopia is a smallholder free range scavenging production. Most birds are reared in small flocks under a scavenging system where under household refuse, homestead pickings, crop residues, herbage and seeds are offered as feed resources by the flock owner (Tadelle, 1996). Halima (2007) reported that 99.28% of farmers provided supplementary feed to their chickens and chickens of different age groups were fed together in Northwest Ethiopia. Likewise, Bogale (2008) reported that 88.9% of flock owners offered supplementary feed to their chickens on top of scavenging in Fogera wereda of Amhara regional state. The same author also reported that maize, finger millet, Barely, Rice, Teff, Injera, wheat, and Sorghum had been used as supplementary feeds, and flock owners gave more supplementary feeds to chickens during the rainy season than the dry season because chickens could not get grain when scavenging due to general shortage of grain during dry season in Fogera woreda. A survey carried out in Northern Gondar of Amhara Regional State by (Wondu *et al*., 2013) indicated that chickens obtained their major feed resources through scavenging with little supplementary feed provision in the study area. Tadesse *et al*. (2013) reported that the dominant system of poultry feeding practiced was free scavenging with supplementary feeding and 94% of respondents provided maize and wheat as additional supplements three times a day in both Ada'a and Lume districts of East Shewa. Additional feed supplementation to chicken was practiced by 97.5% of respondents in Bure district of North West Ethiopia (Moges *et al*., 2010) and 98% of respondents in Jamma district of South Wollo (Mengesha *et al*., 2011). Meseret (2010) reported that 50%, 25% and 25% of respondents offered supplementary green materials, homemade and scavenging on top of purchased commercial poultry ration to their chickens, respectively, in Gomma wereda of Jimma zone.

Similarly, the findings of survey conducted in Uganda disclosed that 98% of respondents provided supplementary poultry feeding to their flocks during the harvesting season and whole grains (maize, simsim, millet and rice) and mill by-products (maize bran and sometimes mixed with silver fish and cotton seed cake) and Kitchen wastes, home-mixed rations and commercial feeds were used as supplementary feeds (FAO, 2009a). In study conducted in Amatola Basin of the Eastern Cape Province of South Africa by (Nyoni & Masika, 2012) indicated that 96.3% of households provided drinking water and feed supplements to chickens on top of scavenging and supplementary feeds were offered twice per a day (morning and evening) by most of flock owners. The same authors also reported that supplementary feeds given to chicks were grounded in to smaller particles for easy consumption and yellow maize, kitchen wastes, sunflower cakes, growres' mash for chicks ad wheat were used as supplementary feeds in the study areas.

2.5.1.4. Housing

In survey conducted in Ada'a and Lume districts of East Shewa by Tadesse *et al*. (2013) revealed that 91.11% in Ada'a and 95.6% of respondents in Lume districts, constructed a separate house entirely for poultry, where as 4.44% of respondents constructed Separate house with other animals in Ada'a, 4.44% in Ada'a and 4% of respondents in Lume districts share the same house with people. Similarly, Fisseha *et al*. (2010) reported that 22.1%, 59.7% and 97.6% of village chicken owners construct separate overnight shelter for chickens in Bure, Fogera and Dale districts of Ethiopia, respectively while the rest chicken owners keep chicken in various night sheltering places.

The findings of the survey carried out in villages of Bangladesh by (Billah *et al*., 2013) indicated that poultry rearing and management practices were not satistifactory. Approximately 30% of farmers kept poultry in their living houses, 46% in earthen houses, 1 0% in wooden houses or tin sheds, 8% in wooden houses or bamboo houses and 6% in concrete houses. According to Nyoni & Masika (2012), different forms of housing structures were provided for the chickens (96.7%) but 3.7% of chickens were roosted over night in open spaces in Amatola Basin of the Eastern Cape Province of South Africa. Chicken houses were constructed using a wide range of materials. All structures were roofed with iron sheets. 8.6% of structures had solid walls, 14.8% had wire mesh and 76.5% had a combination of iron sheets and wire mesh.

2.5.1.5. Constraints of poultry production

The productivity of local chickens is lower than exotic breeds. The low productivity of indigenous chickens is mainly attributed to the low genetic potential, feed (quality and quantity) shortages and prevalence of diseases and parasites in the Tropics (Alexander, 2001 and Hunduma *et al*., 2010). A survey conducted in Gomma wereda of Jimma zone by

(Meseret, 2010) disclosed that Newcastle disease, infectious bronchitis, external parasites, and coccidiocis to be disease of economic importance that devastates poultry production in the Wereda. Similarly, Wondu *et al*. (2013) reported that disease, predators, shortage of supplementary feeds, poultry housing problem and lack of veterinary health services in ascending order, were the most important constraints of poultry production in Northern Gondar of Amhara Regional State.

According to Hunduma *et al*. (2010), diseases and predators, lack of proper health care, poor feeding and poor marketing information were the critical constraints of village poultry production in Oromia Rift Valley of Ethiopia. Replacement of indigenous chickens by exotic chicken breeds is also found to be a major threat in eroding and dilution of the indigenous genetic resources and New castle disease is the major economically important health constraint that hinders the expansion of village chicken production in the study area. The findings of the survey conducted in Ada'a district of the Eastern Shoa zone of Ethiopia (Selam and kelay, 2013) revealed that predation and diseases are the major causes of mortality in chicken older than 7 days and more than half of hatched chicks are lost due to mismanagement, predation and other causes (bad weather, cold, hot, cannibalism and low mothering ability). Diseases, Predators and wild birds are found to be the major causes of chicken death in Fogera district of Amhara region **(**Bogale, 2008). Ayalew & Adane (2013) reported that poultry diseases, inadequate veterinary and extension services and high feed costs are the major constraints affecting village chicken production in selected Chagni town in Awi-administrative zone of Amhara region in Ethiopia. Addisu (2012) also reported that disease (60.13%), predators (20.59%) and feed shortage (19.28%) were the critical constraints of scavenging chicken production in districts of North Wollo, Amhara regional state, Ethiopia. Dawit (2010) recently reported that poultry production was constrained by diseases, health services and limited supply of exotic chickens in Alamata and Atsbi-Wonberta of Tigray. New castle, Salmonella and Chicken flies were found to be major economically important diseases in both study districts. A study carried out in two villages of Bangladesh by (Billah *et al.*, 2013) revealed that diseases, inadequate supply of vaccine and medicine, shortage of feed and predator were the most prominent identified problems of poultry production in both villages (Parkochua and Baraticry). Likewise, prevalence of diseases and parasites and predators were found to be main constraints of poultry production in Amatola Basin of the Eastern Cape Province of South Africa (Nyoni & Masika, 2012).

2.5.1.6. Marketing systems of village chickens and eggs

Income generation from the sale of live chickens and eggs is the main reason behind rearing free range chickens by small holder farmer in different areas of Ethiopia. Smallholder farmers usually sell their chickens and eggs in local and urban markets to traders (collectors) or directly to consumers depending on the location of their residential areas. According to Meseret (2010) live chickens and eggs are sold either at farm gate, small village market (primary market) or at larger wereda market (secondary market in the town) and they pass through different individuals before reaching to consumer in Gomma wereda of Jimma zone in Oromia regional state of Ethiopia. Similarly, Fisseha &Tadelle (2010) reported that there was no any formal chicken and egg marketing operation and 69.3% and 99.6% of interviewed village chicken owners involved in marketing of chicken and eggs, respectively, in Bure district of North-West Ethiopia. Their findings also revealed that Producer-Consumer, Producer-Middle men, Producer-Retailer, Middle men-Retailer, Middle men-Consumer were the prevailing chicken and egg marketing channels of the study district.

Halima (2007) reported that village chicken owners sell their chickens and eggs to purchase food items, pay school fees, get cash for grain milling services, purchase of improved seeds and other expenses in North western of Ethiopia. Consumers usually prefer to purchase eggs and chickens of indigenous birds since they are considered to be tasty and better suited for preparation of the traditional ‘Doro wot’ and dark colored egg yolks are commonly favoured in the study area. The prices of live chickens and eggs are highly affected by seasonal demand and fasting seasons, lack of infrastructures, plumage color, comb type, body size (weight), age, sex, market site and health status of the birds(disease outbreak) in North West Ethiopia (Halima, 2007) and in Gomma wereda of Jimma zone of Oromia regional state (Meseret, 2010).

Likewise, chicken type (sex, age, color and comb type) played an important role on market price of live birds in Bure district of North-West of Ethiopia (Fisseha & Tadelle, 2010). Moreover, their study showed that plumage color and comb type are considered as main determinant factors in selection of birds for production, consumption and marketing purposes by village chicken owners.

Red & white plumage colors were most preferred and demanded highly in the chicken marketing system, and regarding comb type, double (rose) comb was more privileged than single comb types in terms of preference, market price and demand in Bure district. Similarly, Bogale (2008) reported that *kei*, *Netch*, *Seran* and *Libework* ecotypes had better market (10 Birr higher) and more preferred to other ecotypes for consumption, and village chicken owners preferred selling *Tikur*, *Gebsima*, *Teterima* and *Kokima* ecotypes than consuming at home in Fogera district. This is due to deep-rooted stigma attached to this color. The same author reported also that Non-single (pea &Rose) comb, *Netch* and *Key* cocks and cockerels had higher prices (as much as 5 Birr) than single comb ecotypes even within the same plumage color in the same study district.

2.5.2. Functional traits of indigenous chicken ecotypes

Functional traits of local chicken stocks are traits that require frequent follow up (monitoring) or observation for studying them under farmers' management conditions (Bogale, 2008). Functional traits include: average number of Clutch size per hen per year, average number of eggs laid per clutch per hen, average number of eggs incubated, average number of eggs wasted, average number of chicks hatched, average number of chicks weaned, average age of breeding hen and cocks, ratio of breeding hens to breeding cocks, average weight of breeding hens and cocks, average number of breeding replacement male and female, average number of females for egg production, average number of males and females for meat production, average weight of different age groups of a flock, average egg weight, average number of hens laying eggs, average number of hens sitting on eggs, average number of hens looking after chicks and idle hens. Generally, functional traits are traits related to hen production activities and breeding and non breeding structure of a flock.

Bogale (2008) reported the average number of eggs laid per clutch, average number of eggs incubated, average number of chicks hatched, average number of eggs wasted, average number of chicks weaned and average age of Fogera hens (months) under extensive management condition was 13.19,12,97,10.23,3.47,7.63 and 19.2, respectively. The same study also showed that the average weight of 6 month Fogera pullets and cockerels was 933.33±33gm and 1125±25gm ranging from 900-100 gm and 1100-1150 gm, respectively. 28.93%, 22.22%, 34.26% and 17, 59% of Fogera hens were found to be laying eggs, sitting on eggs, looking after chicks and idle hens, respectively. The average weight of day old Fogera chicks was found to be 28.76 ±2.15 gm ranging from 22.22-43gm which is comparable with result reported by Halima (2007) under intensive management in North West Ethiopia which was 27.3 gm.

2.5.3. Effective population size of indigenous chicken ecotypes

Effective population size (Ne) is defined as the number of breeding individuals in an idealized population that would show the same amount of dispersion of allele frequencies under random genetic drift or the same amount of inbreeding as the population under consideration (Wright 1931, 1938). Franklin (1980) developed the 50/500 rule-of-thumb: the *Ne* should not be less than 50 in the short term (increased probability of extinction because of genetic effects) and *Ne* should not be less than 500 in the long term. An effective size of 50 was proposed as a minimum to protect against short-term loss of fitness due to inbreeding, based on empirical observations of the decreasing fitness –related traits with incremental inbreeding in a variety of animal species while the 500 number was proposed as the minimum size necessary to ensure long-term maintenance of genetic variations, thereby preserving evolutionary options for future adaptation.

Effective population size is a parameter used to estimate the rate of inbreeding and genetic drift on the basis of number of breeding individuals in an ideal population (Abdelqader *et al*., 2007). It is a measure of genetic variability within a population with large values of Ne indicating more variability and small values indicating less genetic variability (Maiwashe *et al.*, 2006; Cervantes *et al*., 2008). It was reported that the effective population size (Ne) and the rate of change of inbreeding coefficient (ΔF) of Fogera flock chicken under farmers' management conditions was 3.9 and 0.1282 (12.82%), respectively (Bogale, 2008).

This indicated that the flock population is vulnerable to inbreeding depression as the value of inbreeding coefficient is high and effective population is very low. Likewise, Abdelqader *et al*. (2007) reported that the average effective population size of local chickens kept under different levels of management practices in the rural areas of northern districts of Jordan was 15.35, which indicated a high rate of inbreeding (5.25%). A study on indigenous turkey flock carried out in Nasarawa state of Nigeria by Yakubu *et al*. (2013) revealed that the effective population size (Ne), tom: hen ratio and the rate of inbreeding (ΔF) for the Nigerian indigenous turkey flock considering the existing flock size and management practice was 396, 1:2.75 and 0.0013 (0.13%), respectively, which indicated that the population is not at the risk of extinction.

2.5.4. Breeding objectives and trait preferences of farmers

Breeding objectives defined as the traits to be improved, the cost of production and the revenue from the product sales related to a genetic change in each trait. The farmers' decision of breeding objectives and selection criteria could be affected by breed, production system, production environments and flock/herd size (Jabbor *et al*., 1998; Wokfova *et al*., 2005). Thus, better understanding of the production environments and production systems enables breeders to identify breeding objectives and trait preferences of flock owners and to design effective and sustainable agro-ecologically based breeding programs.

Fisseha *et al*. (2010) reported that the major purposes of village chicken rearing in Bure district of Ethiopia were; sale for income(51%), egg hatching for breeding/replacement stock (45%), home consumption (44%), use of chicken for cultural and /religious ceremonies (36.4%) and egg production (40.7%). Hatching / replacement (71.7%), sale for cash income (58%) and home consumption (68.6%), respectively, are found to be the first, second and third purposes of egg production in Bure district.

Despite the fact that control mating of chicken in free scavenging production system is difficult, farmers have their own selection criteria and strategies of selecting chickens for breeding based on plumage color, comb type, egg production and growth rate (Halima, 2007; Bogale, 2008 and Fisseha *et al*., 2010). Bogale (2008) reported that egg production (1^{st}), plumage color (2^{nd}), Growth rate or body weight (3^{rd}) and comb type (5^{th}) are the main selection criteria used for selecting breeding chicken in Fogera wereda. *Key*, *Netch*, *Seran*, and *Ambesma* cockerels are found to be more expensive than *Tikur*, *Gebsima*, *Kokima* and *Teterima*. Non-single (Pea and Rose) comb *Netch* and *Key* cocks and cockerels had reportedly higher prices (as much as 5 Birr higher) than the single combs of the same color in local markets of the study district. Similarly, Plumage color, live weight, comb type and body conformation "Qumena" are reported to be main selection criteria in five districts of Ethiopia (Nigussie *et al*., 2010b).

Village chicken owners also practice culling of individual chicken from their flock based on different factors (Criteria). For example, the culling factors used by farmers, in order of importance, in Gomma wereda were sickness (36.1%), frequent broodiness (22.8%), sickness and old age (12.2%), lack of broodiness (8.3%), old age (7.2%), lack of broodiness and frequent broodiness (5.6%) and others, as per the reports of Meseret (2010).

As far as trait preference is concerned, trait preference of flock owners varies from area to area and production environment to production environment. Farmers in the Amhara (Farta) and Oromia (Horro) regions give the highest emphasis for plumage color where as farmers in the Southern region of Ethiopia (Konso and Sheka*)* select live weight of chicken as primary trait interest. Comb type and plumage color were found to most preferred traits in Fogera district (Bogale, 2008) and in Bure district of North West Ethiopia (Fisseha *et al*., 2010).
Bogale (2008) also reported that double comb type (pea and rose) is preferred to single comb type and *Key*, *Netch*, *Seran*, and *Ambesma* ecotypes are highly preferred to other ecotypes (*Tikur*, *Gebsima*, *Kokima* and *Teterima*) in Fogera district of Ethiopia. It also reported that red was the most preferred (83.6%) plumage color, followed by white (83.5%). Regarding comb type of local chicken, while rose/-double comb was the most preferred (81.1%) in Bure

district (Fisseha *et al*., 2010). This was mainly attributed to the preference of consumers in the market and presence of cultural attitude in favor of rose comb.

Similarly, Addisu (2012) recently reported that number of egg laid/clutch (37.91%) and plumage colour (37.58%) were the major preferred trait by the farmers, and egg production , meat yield and diseases resistance were found to be most preferred traits by farmers to be improved through breeding program in districts of NorthWollo, Amhara regional state, Ethiopia. Abdelqader *et al*. (2007) reported egg production was the main selection criteria adopted by farmers and, hatchability, survivability, flock size, number of clutches, egg weight and egg mass of local chickens were the major traits improved significantly with improvement in management levels in the rural areas of northern districts of Jordan.

2.5.5. Productive performances of indigenous chicken ecotypes

Indigenous chicken ecotypes of Ethiopia are characterized by low productivity performances. This is attributed by low egg production potential, longer reproductive cycles, slow growth rate, late maturity, produce small sized eggs, small clutch size, broodiness for extended period and high mortality of chickes, predators and feed shortage (Bogale, 2008; Fisseha, 2009; Meseret, 2010; Addisu, 2012; Selam & kelay, 2013; Ayalew & Adane, 2013).

2.5.5.1. Egg production

Average annual egg production of indigenous chicken ecotypes under extensive management condition was 30-60 eggs, and this could be improved to 80-100 eggs on station with improved management (feeding, housing and health care) (Nigussie & Ogle, 2000). The annual egg production performance of local hen under farmers’ management conditions was found to be 60 eggs/hen ranging from 24-112 eggs in Bure district North West Ethiopia (Fisseha, 2009). Meseret (2010) also reported that the mean annual egg production of the indigenous local hens of Gomma wereda was 43.8 eggs/year/hen, which is comparable result to the reported ranges of 18-57 eggs in North West Ethiopia by (Halima, 2007) and 27-45 eggs/ year/hen in Chagni town, Awi administrative zone of Amhara region by (Ayalew &

Adane, 2013) but are lesser than the means of 60 eggs, 53 eggs and 55 eggs reported by Fisseha *et al*. (2010) in Bure, Fogera and Dale districts of Ethiopia, respectively. The findings of another study revealed that average annual eggs/year/hen was 62.95±2.29, 54.9±3.27 and 51.44±1.40 in Wonsho, Loka Aabya and Dale weredas of Southern Ethiopia (Mekonnen, 2007). Another recent study's result revealed that the average eggs laid per year per hen under farmers' management condition was 65 eggs in Enebsie Sar Midir Woreda of Eastern Gojjam (Yitbarek & Zewudu, 2013).

2.5.5.2. Meat production of indigenous chicken ecotypes

Ethiopian local chicken ecotypes are characterized by very low meat production ability even though they can rear with minimal inputs and are adaptive to harsh and stress environmental conditions. Research results indicated that the live weight of indigenous chicken is about 1.6 kg and 1.3 kg for male and female respectively at six month of age (Mekonnen, 2007).

The carcass weight and dressing percentage of male and female chicken was 878.6 gm and 543.8gm, and 58.5% and 49.38% at 10. 6 and 13.6 months age, respectively under scavenging condition of Fogera district of Amhara region (Bogale, 2008). The same study indicated the average live weight of a male chicken at the age of 10.6 months (1540gm) was found to be higher by 28.6% than a female at an average age of 13.6 months (1100gm). Another study revealed that both sexes of RIR breed were superior to both sexes of local breed in slaughter weight and carcass weight at an estimated age of 22 weeks under intensive management of Andassa Livestock Research Center (ALRC) (Halima, 2007). However, similar dressing percentage performances were reported between both sexes of both breeds, and in some cases, both sexes of local breed had slightly better dressing percentage performance than both sexes of RIR breed at the same estimated age, time and management in the same study area.

2.5.6. Reproductive performances of chickens

The reproductive performance of village indigenous chicken ecotypes of Ethiopia is relatively very low as compared to exotic breeds because of their longer reproductive cycles or low genetic potential (slow growth rate, late sexual maturity and broodiness for an extended period) and prevalence of diseases and parasites and poor managements like inadequacy of feeds (quality and quantity), poor housing and others. But it could be improved by genetic improvements through selective breeding along with adequate nutrition and proper management. According to CSA (2009/10) the average length of a single clutch period per hen is estimated to be about 21, 38 and 159 days for local, hybrid and exotic breeds, respectively. The average number of eggs laid per hen per egg- laying period in the country is about 12, 33 and 135 eggs for local, hybrid and exotic breeds respectively.

It is also estimated that, under scavenging conditions, the reproductive cycle of local hens consists of 20-days of lying phase, 21-days of incubation phase and 56-days of brooding phase with a total of 97- days (Alemu & Tadelle, 1997). Sonaiya & Swan (2004) also reported that indigenous village chicken, in Ethiopia attains sexual maturity at an average of 7 months. The hen lays about 36 eggs per year in 3 clutches of 12 to 13 eggs in about 16 days. Each reproductive cycle lasts for 17 weeks. Three cycles then make one year. Different scholars pinpointed that egg production of a broody local hen can be increased by using different traditional methods of breaking broodiness. For example, Tadelle *et al*. (2003b) in some selected areas of Ethiopia, Fisseha (2009) in Bure wereda of North West Amhara region, and Matiwos *et al.* (2013) in Nole Kabba Woreda of Western Wollega report traditionally all households attempt to increase egg production by stimulating broody hens to resume laying. These include piercing the nostril with a feather to prevent sitting, changing the hen's house/physically moving the hen to nearby house for a couple of days was found the most preferred practice implemented, hanging the hen upside down for a limited period of time each day for about 3-4 days and spraying water on hen's body and its place and also dipping broody hen in water. The basis of these practices is to disturb the broody hen and to cause a hormonal shift s that it restarts to lay eggs within 8-10 days.

Similarly, the traditional methods of breaking broodiness as practiced by the community of Gomma wereda and in their order of importance were disturbing the broody hen in the nest (48.9%), hanging the hens upside down (18.9%), disturbing the broody hen in the nest, moving to neighbor (15.6%), disturbing the hens in the nest and moving to neighbor (7.8%), depriving the hens from food and water (5%) and, hanging the hens upside down and depriving the hens from food and water (2.2%), as per the reports of Meseret (2010). The same author also reported that male and female local chicken attain sexual maturity at an average of 6.47±0.91 and 6.33±0.80 months, respectively, under scavenging conditions of Gomma wereda of Jimma zone of Ethiopia.

The average age for slaughter (8.62±1.92 months), number of days per clutch (25.29±4.39), number of chicks surviving to an age of 5-months (2.82±0.92), number of times the hen hatches per year (1.85±0.51), hatchability (22%), chick mortality (41%) and weaning age (2.61±0.45 months) of the indigenous village chicken were also reported by the same author in the same time and study area. In Nole Kabba Woreda of Western Wollega, the findings of recent research revealed that the mean age at first egg laying and hatchability of indigenous and RIR cross pullets were 7.02±0.22 days and 5.66±0.116 days, and 82.74% and 44.36%, respectively, under scavenging production conditions (Matiwos *et al.*, 2013). A study on three exotic chicken breeds (Isa Brown, Bovan Brown and Potchefstroom Koekoek) by Tadesse *et al*. (2013) revealed that the average age at first laying of Isa Brown, Bovan Brown and Potchefstroom Koekoek was 160.5±13.5, 165.5±13.2 and 153.3±6 days, respectively, under village production system in Ada'a and Lume districts of East Shewa in Ethiopia.

In Sudan, the findings of a research on two Sudanese native chicken ecotypes indicated that the average clutch length, average number of eggs per clutch, number of clutches per hen per year, hatchability using natural incubation, age at sexual maturity and fertility of Dwarf (Betwil) and Bare Neck ecotypes were 14.44 days, 9.89 eggs, 5, 65.6%, 163.9 days and 76.08%, and 20.04 days, 13.52 eggs, 4, 59.09%, 184.9 days and71.31%, respectively, under improved traditional production system (Yousif & Eltayeb, 2011).

2.5.7. Quantitative traits of indigenous chicken ecotypes

There is a variation in quantitative characteristics (body measurable traits) within and between Ethiopian local chicken ecotypes. They vary in body weight, height at back level, body weight, body length, wing span, wattle length, comb length and width, earlobe length and spur length. Halima (2007) reported that average shank length for hens and cocks is 8.14cm and 10.31cm, respectively which is comparable to average shank length of hens and cocks (7.25±0.16 cm and 9.82±0.12 cm) and (7.0±0.7 cm and 9.1±1.1 cm), respectively reported by Bogale (2008) in Fogera district of Amhara region under extensive management and by Nigussie *et al*. (2010a) in five selected weredas of Ethiopia.

Similarly, comparable results reported in Average wing span of hens and cocks (13.36 cm and 15.38 cm), and (12.57±2.11 and 15.88±0.51), respectively by Halima (2007) and Bogale (2008). In Spain, Francesch *et al*. (2011) reported that the average wing span of Adult hens of Penedesenca and Empordanesa breeds under intensive management was 76.405±0.5 cm and 75.84±0.5 cm, respectively.

2.5.8. Qualitative traits of indigenous chicken ecotypes

Ethiopian indigenous chicken ecotypes are heterogeneous population with no standardized characteristics and performances. They vary morphologically in body size (small, medium & large), plumage color, comb type, comb color, skin color, earlobe color, eye color, egg shell color, head and body shape, shank feather and color, feather morphology, feather distribution and growth (Duguma, 2006; Halima, 2007; Bogale, 2008). This indicates the presences of a considerable diversity of phenotypic characters within and between indigenous chicken ecotypes and used as a potential for genetic improvement of local chicken ecotypes through selection.

Plumage color varies with red, white, black or grayish dominating. Rare color patterns are key Teterima, Libework, multicolor Anbsema, Seran and red brownish Kokima (Halima, 2007; Bogale, 2008) and naked nack (Duguma, 2006). There is also variation in comb type and color, shank color, earlobe color, wattle color and skin color. The commonest comb-types of indigenous chicken are rose, pea, walnut/strawberry, single and V-shape. Most of the indigenous chickens have no shank feathers (Halima, 2007; Bogale, 2008; Faruque *et al*., 2010) and shanks are yellowish in color (Halima, 2007; Bogale, 2008; Nigussie *et al*., 2010a). The commonest egg color of indigenous chicken is white (Faruque *et al*., 2010).

2.5.9. Carcass characteristics of indigenous chicken ecotypes

Carcass traits are indicators of the meat production ability of livestock breed(s). Carcass traits are affected by different factors such as genetic structure of the flock or genetic factors (eg. Breed, strains, lines etc) and environmental factors (nutrition, rearing practices (breeding), health, flock management, environmental conditions, temperature, relative humidity and season). Carcass traits include: pre–slaughter weight, slaughter weight, carcass weight (dressed weight), dressing percentage and others.

Bogale (2008) reported that the average slaughter weight, carcass weight and dressing percentage of hens and cocks of local chicken ecotypes under extensive management in Fogera district was 1100gm, 543.8gm and 49.38, and 1540 gm, 878.6 gm and 58.5, respectively. Likewise, the pre-slaughter weight, dressed weight and dressing percentage of finisher female and male under intensive management in North West Ethiopia was found to be 642±229.68 - 873.5±499.92 gm, 387±142.45- 570.33±72.57 and 56.33±0.08-73.33±0.18, and 1044.67±214.97 - 1517±288.75, 625.33±272.78- 955.33±209.12 and 53.33±0.15-66.67±0.08, respectively (Halima (2007) . In consistent to these results, Addisu (2012) recently reported that the average age at sexual maturity and mature mean body weight for male and female indigenous chickens under scavenging management conditions in North Wollo zone of Amhara region were (24.25±0.04 and 23.84±0.05) weeks and (1500.97 and 1253.36) grams, respectively. However, Alemu and Tadelle (1997) reported that the carcass weight of cocks under extensive management in centeral Ethiopia was 550 gram.

3. MATERIALS AND METHODS

3.1. Description of Study Area

The study was conducted in the three rural weredas (Kafta Humera, Welkait and Tsegede) of Western Zone of Tigray Regional State, North West Ethiopia. It is one of the five administrative zones of Tigray regional state and it has 4 districts (Setit Humera, Kafta Humera, Welkait and Tsegede) comprising of 81 kebeles in which 77 kebeles are rural (24, 25 and 28 kebeles from Kafta Humera, Tsegede and Welkait weredas, respectively) and 4 urban kebeles with distance that ranges 580–750 km from Mekelle, the capital city of Tigray.

It covers an area of 1.5 million hectare with Kafta Humera accounts 48.13%; Setit Humera accounts 0.82%, Tsegede accounts 23.43% and Welkait accounts 27.62% (HuARC, Unpublished). The total cultivated land of the zone is 573,285 hectares (38.2%) while the uncultivated land accounts 927,000 hectares (62.8%). Of the total, 36.8% of the uncultivated land (341,195.25 hectare) is covered by different plant species excluding Boswellia and Acacia Senegal while 185,510 hectares (20%) of the unfarmed land is solely covered by both Boswellia and Acacia Senegal. The zone consists of three agro-ecological zones (lowland, midland & highland) in which kolla (lowland) represents 75%, weynadegga (midland) account for 15.7% and dega (highland) account for 9.3% of the land coverage of the zone.

The geographical location of the zone is 13°42′ to 14°28′ north latitude and 36°23′ to 37°31′ east longitude (Mekonnen *et al.*, 2011). The annual rainfall of the zone ranges from 600 mm to 1800 mm while the annual temperature ranges from 27^0c to 45 ^{0}c in the lowland areas (Kolla) and 10^0c to 22 ^{0}c in both midland and highland areas of the zone. The altitude of the zone ranges from 500- 3008 m.a.s.l. The zone shares borders with Tahtay Adibayo, Tselemti and Asgede Tsimbla in the East, Sudan in West, Amhara region in South and Eritrea in the North. The study area represents a remote, tropical climate where extensive agriculture is performed manually by large numbers of migrant laborers.

Throughout the zone, livestock is the predominant economic activity with about 95% of the total population engaged directly or indirectly in it (Mekonnen *et al*., 2011). Main cattle breeds raised in the Western Zone are the local Arado (in both high land and mid land areas) and Begait cattle (in lowland areas). Semi-intensive production is practiced in Humera district, which is more urban, while extensive production system is dominant in the Welkait and Tsegede districts. The main crops cultivated in the lowland areas of the zone are sesame, cotton and sorghum while teff, wheat, barley, noug, lentils, finger millet, field peas and fababeans are cultivated crops in both midland and high land areas of the zone.

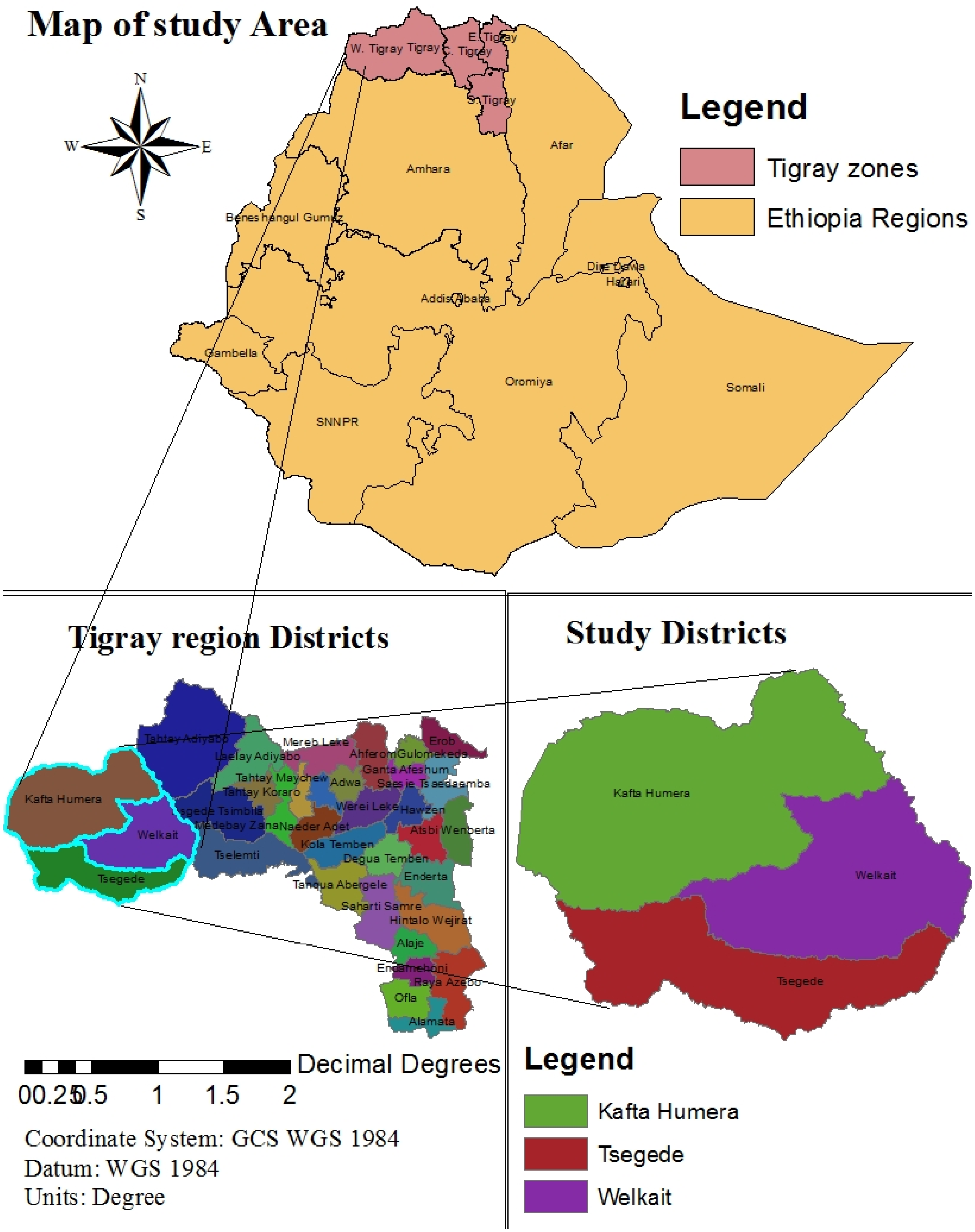


Figure 1: Geographical Map of Study Areas

3.1.1. Human and livestock demography

The total human population of the zone is estimated at 357,547. Of the total population, men account for 51.3% (183,547) and women account for 48.7% (174,000). The total agricultural households of the zone are 81,468.The zone has great potential for livestock production. According to the report of the Agricultural and Rural Development office of western zone (2013) estimate, the zone has 752,264 cattle, 315,431 goats, 223,466 sheep, 416,322 chickens, 30,185 donkeys, 5,308 camels,11,113 swines, 21,329 honeybees, 6,120 modern hives and 2,405 mules (Table 4).

Table 4: Total livestock population of each livestock species / each rural wereda of the western zone

S.No	Livestock species	Welkait	Tsegede	Kafta humera	Total
1	Cattle	245400	269557	237307	752264
2	Goat	91305	120510	103616	315431
3	Sheep	208	40867	182391	223466
4	Chickens	168206(40.4%)	135433(32.5%)	112683(27.1%)	416322
4.1	Local	161960	132477	110840	405277
4.2	Exotic	6246	2956	1843	11045
5	Donkey	5362	1294	23529	30185
6	Camel	196	1438	3674	5308
7	Swine	1573	7500	2040	11113
8	Honey bees	11318	7011	3000	21329
9	Modern hives	2585	1843	1692	6120
10	Mule	724	1681	-	2405

Source: Agriculture & Rural Development office of western zone report, 2013, unpublished.

3.2. Sampling Techniques

The western zone of Tigray comprises of three rural weredas (Kafta Humera, Tsegede and Welkait weredas) and one urban weredas namely Setit Humera wereda. Discussions were held with the experts of the Rural and Agricultural Development office of the zone to know the current poultry production potentials and village poultry population densities of the zone. Based on the outcome of the discussion, the three rural weredas were purposely selected for the study based on the zonal representation level of village poultry production.

Stratified sampling technique was employed to stratify Kebeles of both Welkait and Tsegede weredas in to lowland or kola (<1500 masl), midland or waina dega (1500-2500masl) and highland or dega (>2500masl) while kebeles of Kafta Humera was stratified in to lowland and mid land as it is only comprises of kola (lowland) areas and mid land areas. This was done in collaboration with the experts of both zonal and each respective rural weredas Agricultural and Rural Development Office.

Multi-stage sampling procedure that involved purposive and random sampling techniques was employed to select both sample kebeles (smallest administrative unit in Ethiopia) and respondents (local chicken owners). Sample Kebeles were selected purposively to represent the three agro-ecologies based on the village poultry population density, chicken production potential, road accessissibilty and agro-ecology representation level of the zone.

A total of nine kebeles were purposely selected, where representative kebeles from each selected agro-ecology with four kebeles from low land agro-ecology of the zone (one kebele from low land of Welkait, one kebele from low land of Tsegede wereda and two kebeles from lowland of Kafta Humera wereda because it is the largest wereda with large low lowland areas); three kebeles from mid land agro-ecology (one kebele from each rural wereda) and two kebeles from the high land agro-ecology (one kebele from each Tsegede and Welkait wereda only because there is no highland areas in Kafta humera wereda) (Table 5). Similarly, farmers (village chicken owners) were selected purposely from the respective selected sample kebeles based on poultry production experiences and possessing three or more chickens.

A total of 385 village chicken owners were randomly chosen and the number of respondents per each sample kebeles was determined by proportionate sampling technique based on the households' size of the sample kebeles and they were interviewed using a pre-tested structured questionnaire.

Table 5: Samples kebeles and required respondents / kebeles for the study

Agro –ecology	Total HHs	Land coverage (%)			Required HHs/agro-ecology
Lowland(Kolla)	33,727	75%			160
Midland(Wenadega)	27,632	15.7%			131
Highland(Dega)	19,820	9.3%			94
Total	81,179	100%			385
Sample kebeles and required respondents by proportionate sampling techniques					
S. kebele	Wereda	Agroecology	Altitude(m.a.s.l)	Total HHs	Required HHs
Baheker	K.Humera	Lowland	698	1953	45
Adebay	K.Humera	lowland	604	2817	64
Dansha	Tsegede	Lowland	780-800	1387	32
Maygeba	Welkait	Lowland	740	810	19
Total per agro-ecology				6967	160
Adihirdi	K.Humera	Midland	1818	3167	62
Wef-argf	Welkait	Midland	2064	2281	45
Endasilassie*	Tsegede	Midland	2386	1174	24
Total				6622	131
Endamariam	Tsegede	Highland	2865	1096	41
Welel	Welkait	Highland	2770	1384	53
Total				2480	94

NB: * =excluding Embagahalit village; K.Humera=Kafta Humera; S.Kebele =sample Kebele

Total HHs = Total number of households living per kebele or agro-ecology

Required HHs = required number of households /kebele or agro-ecology & was Determined by proportionate sampling technique

3.3. Sample Size Determination

Sample size determination is the first basic part of research project methodology. Appropriate sample size has a paramount significance in drawing concise inferences (summarization) about the subject that is under study.

There are several strategies used for determination of appropriate Sample size. Sample size for the proportion developed by (Cochran, 1963) is frequently preferred strategy for large population (infinite population or >50,000).

$N_o = \underline{Z^2pq}/e^2$, Where $N_{o=}$ required sample size

Z^2 =is the abscissa of the normal curve that cuts off an area at the tails (1 - α equals the desired confidence level, e.g., 90%, 95%, 99% confidence level) and the Z values for most commonly used confidence level (90%=1.645; 95%=1.96 and 99%=2.576)

e = is the margin of error (eg. ±0.05% margin of error for confidence level of 95%)

p = is the degree of variability in the attributes being measured refers to the distribution of attributes in the population or the estimated value for the proportion of the sample that will respond a given way to a survey question.

The more heterogeneous a population, the larger the sample size required to obtain a given level of precision. The less variable (more homogeneous) population, the smaller the sample size. And a proportion of 0.5(50%) indicates the maximum variability in a population; it is commonly used in determining a more conservative sample size.

q= 1-p.

For survey the required sample size of respondents (local chicken owners) with 95% confidence level was calculated as, **$N_o = \underline{Z^2pq}/e^2$** = $[(1.96)^2$ x (0.5) (0.5)]/ (0.05x0.05)

= [3.8416 x0.25]/ (0.0025)=0.9604/0.0025=385 farmers.

The numbers of respondents (farmers) per single selected kebele were determined by proportionate sampling technique as follows:

W= [A/B] x N_o, where **A**=Total number of households (farmers) living per a single selected kebele

B= Total sum of households living in all selected sample kebeles and

N_o = the total required calculated sample size

3.4. Data Collection

3.4.1. Production system description

A questionnaire was designed to collect primary data on household characteristics (Annex 1), production systems or poultry husbandry practices (Annex 2), breeding practices (Annex 3), incubation practices (Annex 4), productive and reproductive traits (Annex 5), village chicken production constraints and opportunities (Annex 6) and adaptability traits (Annex 7).

After the questionnaire was developed, training was given for enumerators (particularly kebele agricultural development agents) regarding the nature of the survey and the quality of the information required. The questionnaire then was pretested before the actual work to ensure the appropriateness of its design, clarity of the questions, interpretation of the questions by enumerators and farmers, relevance of the questions, quality of data to be recorded and time taken for an interview. Results from the pretest were used to make final refinements to the questionnaire.

Participatory Rural Appraisal (PRA) techniques (ranking, key informant and group discussion, direct observation) was used to collect complementary information to validate the information generated through structured questionnaire. To achieve this, one focus group discussion per each agro-ecology of the zone with a minimum of 10-12 discussants with similar characteristics (gender, age, economical status, religious and etc) (Krueger & Casey, 2000) was established.

General information on total livestock population by species, main crop, topography, climate data (temperature and rain fall), grazing pattern, disease prevalence, livestock husbandry and total population size of each sample weredas of the zone were obtained from secondary data from each Wereda office of Agriculture and Rural development.

3.4.2. Physical characteristics of local chicken ecotypes

Measurement of quantitative traits and visual appraisal of the appearance (observation of qualitative traits) of village chicken ecotypes was done and recorded, using a structured format for morphological description, following standard descriptor (FAO, 2012b).

The minimum number of mature chickens required for phenotypic characteristization is 10-30 cocks and 100-300 hens (FAO, 2012b). Precision increases with increasing sample size. Based on this concept, a total of 770 mature local chickens with two mature chickens (with age of greater or equal to six months based on the sexual maturity of males (6.47months) and females (6.33months), males (5.87±0.01months) and females (5.9±0.11months), and females (5.85 months of age at first egg laying) as per the reports of Meseret (2010), Bogale (2008) and Mengesha *et al*. (2008), respectively) per a single respondent was used for the study. Each Selected samples of Local chickens was individually measured for quantitative traits. A total of 1642 of matured chickens were observed for phenotype expression of (qualitative or discrete traits) (presences of spur, plumage color and pattern, skin color, eye color, earlobe color and shank color and, feather morphology and distribution, comb type, comb size) and others following the phenotypic descriptor developed by FAO (2012b).

Twenty one morphometric traits (body weight, body length, Skull length and width, comb length and width, beak length and width, earlobes length and width, wattles length and width, neck length, wingspan, skull index, comb index, earlobes index & wattle index) were measured based on the methodology developed by FAO (2012b) & Francesch *et al*. (2011).

Selected adult local chickens were weighed using a Sensitive balance with an electronic weighing scale (precision =1 gram) and wingspan, neck length, height at back, height at comb and back length (body length) were measured with a tape measure (±1 mm). Skull length and width, comb width and length, beak width and length, ear lobes width and length and wattles width and length were measured using a calliper (±0.01 mm). Four corporals index were determined following the methodology developed by Francesch *et al.* (2011). They express the relation between the length and width of the structure/respective quantitative trait.

$$\text{Skull index} = \frac{\text{Skull length}}{\text{Skull width}} \qquad \text{Comb index} = \frac{\text{Comb length}}{\text{Comb width}}$$

$$\text{Earlobe index} = \frac{\text{Earlobe length}}{\text{Earlobe width}} \qquad \text{Wattle index} = \frac{\text{Wattle length}}{\text{Wattle width}}$$

3.4.3. Functional traits

Out of the total sample farmers, 10 farmers from each sample kebele were randomly selected and monitored every seven days for three-month duration to describe functional characteristics of the local chicken eco-types in the study area (Bogale, 2008 & FAO, 2012b). This was accomplished with collaboration of trained Agricultural development agents of each sample kebele. During monitoring/home visits, eggs laid per clutch, number of eggs incubated, number of chicks hatched, number of eggs wasted, hatchability rate, survival rate up to one month, two months, three months, age and average weight of day old chicks, a week old chick, a month, two month and three month old chicks were recorded and used for analysis.

3.4.4. Carcass characteristics

Forty eight adult animals with sixteen from each selected agro-ecology consisting of eight male and eight female having typical characteristics were purchased to evaluate the carcass characteristics of local chicken eco-types in the study zone. The chickens used were approximately 10 months up to 12 months in age per information provided by the owner. The live weight of each of the chickens was taken immediately after purchase using a Sensitive balance of weighing scale of one gram precision. Before slaughtering them, the chickens were deprived of feed and water over night and weighted to get the slaughter live weight.

Finally, all the chickens were slaughtered and the carcass was separated from the offal (feather, gastrointestinal tract, giblet shank, lung, head, kidney, and sex organ). Then whole carcass weight was obtained by subtracting offal weight from live weight. The different carcass traits /cuts/ of local chickens were separated and weighed based on the Meat buyers' guide developed by NAMP (2007).

3.5. Breeding Objectives and Farmers' Trait Preferences

A questionnaire was used to identify the breeding objectives and farmers' trait preferences and selection criteria for production and breeding purposes of local chicken ecotypes in each selected kebeles (agro-ecologies) of each respective agro-ecology of the study zone. Farmers were interviewed to identify, rank/score and lists priorities of breeding objectives, farmers' trait preferences and selection criteria, price determinant factors of chicken products, poultry production constraints and poultry diseases. Based on the identified farmers' trait preferences, areas of genetic improvement intervention were identified and prioritized through full participation of farmers (local chicken owners) (Annex 3).

3.6. Statistical Analysis

3.6.1. Qualitative data from the recall survey

The qualitative survey data were analyzed for descriptive statistics using frequency procedures and cross-tabulation of SPSS version 16(2007). The Kruskal-Wallis Test option of the non-parametric tests of SPSS was employed to test the effects of the agro-ecology on the proportion of each qualitative survey data.

3.6.2. Quantitative data for house hold characterization

General linear model procedure of statistical analysis system (SAS 9.2 (2008)) was used to investigate the effects of agro-ecology difference on household characteristics (family size, livestock species wise flock/herd and chicken flock size per household) and various performance related parameters of chickens (such as age at first laying, number of clutches per year, clutch length, eggs/hen per year and others).

Statistical model

$\mathbf{Y_{ij} = \mu + A_i + E_{ij}}$

Where $\mathbf{Y_{ij}}$ = the value of the respective variable mentioned above pertaining to the i^{th} agroecology *(*i = 3, lowland, midland and highland, $\boldsymbol{\mu}$ = overall mean of the respective variable, $\mathbf{A_i}$ = the effect of i^{th} agroecology (i = 3, lowland, midland and highland and $\mathbf{E_{ij}}$ =

random error term. Mean separation was carried using Tukey test for the variables that were statistically different across the agro-ecologies in the analysis.

3.6.3. Qualitative and quantitative traits

The qualitative morphological traits (plumage color and pattern, skin color, eye color, earlobe color and shank color and, feather morphology and distribution, comb type, comb size and others), of the local chicken ecotypes were analyzed for descriptive statistics using frequency procedures and cross-tabulation of SPSS version 16 (2007).The Kruskal-Wallis Test option of the non-parametric tests of SPSS was employed to test the effects of the agro-ecology and sex of chickens on the proportion of each qualitative morphological trait. General linear model procedure of statistical analysis system (SAS) was used to evaluate the effect of sex and agro-ecology on the quantitative traits of each prevailing local chicken types.

$$\mathbf{Y_{ijk} = \mu + A_i + B_j + AB_{ij} + E_{ijk}}$$

Where $\mathbf{Y_{ijk}}$: The corresponding quantitative trait of local chicken in i^{th} agro-ecology (i=3, lowland, midland & highland) and

$\boldsymbol{\mu}$: overall population mean for corresponding quantitative trait

$\mathbf{A_i}$: fixed effect of i^{th} agro-ecology

$\mathbf{B_j}$: fixed effect of j^{th} sex (j=2, male & female)

$\mathbf{AB_{ij}}$: agro-ecology & sex interaction effect and $\mathbf{E_{ijk}}$: residual error

3.6.4. Carcass characteristics and rate of inbreeding

After determination of carcass weight of individual sample local chicken, general linear model was also used to investigate the effect of both sex and agro-ecology difference on carcass weight

$$\mathbf{Y_{ijm} = \mu + W_i + G_j + GW_{ij} + E_{ijm}}$$

Where $\mathbf{Y_{ijm}}$ = The value of the carcass weight of i^{th} sex of local chicken (i=2, male &female) pertaining to j^{th} agro-ecology (j=3, lowland, midland & highland)

$\boldsymbol{\mu}$ =Overall population mean

$\mathbf{W_i}$ = Fixed effect of i^{th} sex of local chicken (i=2, male & female)

$\mathbf{G_j}$ = Fixed effect of jth agro-ecology (j=3, lowland, midland and highland)

$\mathbf{GW_{ij}}$ = Sex by agro-ecology interaction effect and E_{ijm}= residual error

Carcass weight = live weight – offal weight

$$\text{Dressing percentage} = \frac{\text{Carcass weight}}{\text{Live weight}} \times 100$$

Likewise, both effective population size (Ne) and rate of inbreeding (F) were estimated for each agro-ecology separately, using the following formula developed by (Falconer and Mackay, 1996).

$Ne = \frac{4NmNf}{Nm + Nf}$ and the increase in inbreeding per generation (ΔF) = 1/ (2Ne) or (ΔF) =1/8Nm +1/8Nf; Where Nm is the number of breeding cocks, Nf is the number of breeding hens and Ne is effective population size.

3.6.5. Ranking of breeding objective, trait preferences and poultry production constraints.

Participatory farmers' discussions were designed in indentifying the breeding objective traits and farmers' preference traits and deriving their relative importance in the different agro-ecologies of the zone. A total of three independent groups of farmers were established in the zone with one group per agro-ecology. The groups consist of knowledgeable farmers with 10-12 members per a single group.

List of the different breeding objectives traits and farmers preferences traits identified in the interviews were prepared into separate flip charts and presented to each group for rating them according to their order of importance. Similarly, traits affecting consumers preferences in purchasing and/or selling chickens (such as, live weight, sex, plumage color, comb type), "traits" farmers desired to be improved (adaptation, growth, egg production, plumage color," comb type, reproduction), Adaptation traits (disease and stress tolerance, flightiness/ability to escape predators, scavenging vigor) and constraints of village chicken productions was also presented. The ratings of each identified traits and constraints were carried out by assigning different weights (Highest weight = most important and lowest weight, 1=least important) based on their relative importance. Members of Each group were discussed thoroughly and assigned relative weights after arriving on consensus.

Symptoms of each poultry disease were identified during individual interview of the survey. Every identified symptom was translated in to its respective common name based on the case book records of poultry diseases in the Animal Health Clinics of each agro-ecological zone of the study area. This was done with greatest involvement of the experienced veterinarians of Animal health clinics in each agro-ecological zone of the Zone. Upon translation, the common poultry diseases were presented to the established Focused group discussion members of each agro-ecology of the zone for ranking.

The rank of each factor from individual respondent obtained through direct interview in the survey was analyzed using Ranking index:

Index =Σ(n x number of HHs ranked first + (n-1)x number of HHs ranked second +(n-2) x number of HHs ranked third + (n-3)x number of HHs ranked forth +(n-4)x number of HHs ranked fifth +(n-5)x number of HHs ranked sixth +(n-6) x number of HHs ranked seventh +(n-7)+…+ 1xnumber of HHs ranked last) for one factor divided by the Σ(n x number of HHs ranked first+(n-1)x number of HHs ranked second+….+1x number of HHs ranked last) for all factors, and where n = number of factors under consideration (Kosgey,2004).

3.6.6. Multivariate analysis

Principal component analysis, canonical discriminate analysis, step wise discriminant analysis and cluster analysis were performed by Statistical analysis system (SAS) version 9.2 (2008) for each sex separately. Measurable morphological characters of mature local chickens were used to perform principal component analysis. This method enables transformation of a large number of variables into a smaller number of latent variables (principal components, PCs) which are not inter-correlated. Cluster and principal component analyses were computed by using the procedures CLUSTER and PRINCOMP, respectively using SAS software version 9.2 (SAS, 2008).

Step wise discriminate procedure of SAS was applied using PROCSTEPDISC to determine which morphological traits have more discriminate power than others in discriminating the genetic groups. The relative importance of the morphometric variables in discriminating among the three chicken populations was assessed using the level of significance and F-statistics and Partial R^2. The canonical discriminate analysis was computed through CANDISC procedure of SAS in order to perform univariate and multivariate one-way analysis that calculated the mahalanobis distance among the chicken populations (Ogah *et al*., 2011; Al-Atiyat, 2009; Yakubu *et al*., 2011). The ability of these canonical functions to assign each individual animal to its group was calculated as the percentage of correct assignment to each genetic group using the DISCRIM procedure (Gwaza *et al*., 2013; Adekoya *et al*., 2013; Ogah *et al*., 2011; Eskindir *et al*., 2014).

4. RESULTS AND DISCUSSION

4.1. Household Characteristics of the Respondents

Overall, 83.4% of the total respondents were male headed while the remaining 16.6% of the respondents were female headed households (Table 6). There was no variation with respect to the proportion of both sexes of the respondents across all agro-ecologies. However, the proportions of male headed households (80%, 86.3% and 85.1%) were higher than female headed house households (20%, 13.7% and 14.9%), in lowland, midland and highland agro-ecologies of the study area, respectively. However, contrasting results have been reported from Gomma district of Jimma zone (Meseret, 2010), North West Ethiopia (Halima, 2007) and Ada'a and Lume districts of East Shewa of Ethiopia (Tadesse *et al*., 2013) in which the proportions of females (70%, 74.16% and 65.6% & 70%) were higher than males (30%, 25.84%, and 34.4%& 30%) headed households, respectively.

The present study revealed that 97.1% of the total interviewed households were farmers where as the remaining 0.8%, 1.8% and 0.3% of the respondents were merchants, government workers and carpenters, respectively. Proportions of the respondents' occupations did not differ among agro-ecologies. However, highest proportions of the respondents were engaged in farming activities as a means of their livelihood in all agro-ecologies. Similar results have been reported from Gomma district of Jimma zone by Meseret (2010).

The analysis for educational status of the respondents revealed that 41.3% of the respondents were illiterate while 24.4% of them were found to be capable of reading and writing. About 15.3%, 11.4%, 6.5% and 1% of the literate respondents had gone through primary first cycle (1 -4), primary second cycle (5-8), high school (9-12) and diploma program (12 +3), respectively. The proportions of the educational status of the respondents significantly varied across agro-ecologies. The proportions of illiterate respondents in the lowland (34.4%) were lower than in midland (48.9%) and highland (42.6%). This indicates that households in lowland may have better access to educational services as compared with either of the agro-ecologies. Generally, the highest proportions of the respondents were illiterate in each agro-ecology. Educational status identified under the current study was better than illiterate (82.12%) reported from North West Ethiopia (Halima, 2007). However, it was less than from those reported from Bure district of North West Ethiopia (Moges *et al*., 2010), Gomma district of Jimma zone (Meseret, 2010) and both Ada'a and Lume districts of East Shewa of Ethiopia (Tadesse *et al*., 2013).

The result of the survey revealed that 93.5% of the total respondents were Orthodox Christian while the remaining 6.5% of them were Muslim in the study area. There were significant ($p<0.05$) variations with respect to the proportions of respondents following different religious types among agro-ecologies. Higher proportions of Orthodox Christian followers were observed in lowland (97.5%) than in highland (92%) and midland (89.3%) agro-ecologies. However, higher proportions of Muslim followers were obtained from midland agro-ecology (10.7%) than from both highland (7.4%) and lowland (2.5%) agro-ecologies. In contrast, Meseret (2010) reported that 86.1% and 12.8% of the respondents were followers of Muslim and Orthodox Christian, respectively in Gomma district of Jimma zone. Dawit (2010) also reported fairly similar proportion of Orthodox Christian followers (99%) and Muslim followers (1%) in Atsbi-Wonberta wereda but dissimilar proportions of both Orthodox Christian (75%) and Muslim (25%) followers in Alamata Wereda of Tigray region.

The analysis for the marital status of the respondents showed that 82.1% of the total interviewed respondents were married where as the remaining 7%, 10.6% and 0.3% of the respondents were divorced, widow/widower and unmarried, respectively. Proportions of the respondents' marital status were not varied across agro-ecologies. The occurrences of married respondents under the current study (82.1%) was lower than from the result reported from Gomma wereda of Jimma zone (97.2%) (Meseret, 2010) and from western Amhara administrative region (90.3%) (Worku *et al*., 2012) but higher than from frequency of married respondents reported from selected chagni town, Awi-Administrative zone of Amhara region (71%) (Ayalew & Adane, 2013). Existence of both religious in the study area implies that sustainable improved chicken productivity can be achieved if the interest of both religious followers is incorporated in the designing, planning and implementation of holistic chicken productivity strategies.

Table 6: Demographic characteristics of households (% of respondents)

Household characteristics	Agro-ecological zones				X^2-test	P -value
	High altitude (n=94)	Mid altitude (n=131)	Low altitude (n=160)	Total (N=385)		
Sex of households					2.299(ns)	0.317
Male	80(85.1)	113(86.3)	128(80)	321(83.4)		
Female	14(14.9)	18(13.7)	32(20)	64(16.6)		
Household occupation					5.459(ns)	0.065
Farmer	89(94.7)	126(96.2)	159(99.4)	374(97.1)		
Merchant	-	2(1.5)	1(0.6)	3(0.8)		
Government worker	4(4.2)	3(2.3)	-	7(1.8)		
Carpenter	1(1.1)	-	-	1(0.3)		
Educational status					6.126(*)	0.047
Illiterate	40(42.6)	64(48.9)	55(34.4)	159(41.3)		
Read and write	21(22.3)	31(23.7)	42(26.3)	94(24.4)		
1st -4th	15(16)	15(11.5)	29(18.1)	59(15.3)		
5th -8th	9(9.6)	14(10.7)	21(13.1)	44(11.4)		
9th -12th	6(6.4)	6(4.6)	13(8.1)	25(6.5)		
12 +3	3(3.2)	1(0.8)	-	4(1)		
Religion of households					8.116(*)	0.017
Orthodox	87(92.6)	117(89.3)	156(97.5)	360(93.5)		
Muslim	7(7.4)	14(10.7)	4(2.5)	25(6.5)		
Marital status of households					3.058(ns)	3.058
Married	80(85.1)	111(84.7)	125(78.1)	316(82.1)		
Divorced	7(7.4)	7(5.3)	13(8.1)	27(7)		
Widow /widower	7(7.4)	13(9.9)	21(13.1)	41(10.6)		
unmarried	-	-	1(0.6)	1(0.3)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n = number households interviewed.

The result also showed that the average age of the households in both midland (47.92±12.09 years) and lowland (47.46±12.3 years) was significantly ($P<0.05$) higher than highland agro-ecology (42.95±10.82 years) (Table 7). Generally, the average age of the households in the study area was 46.51±12.05 years. This result was much higher than the 36.9 and 37.7 years reported by Tadesse *et al.* (2013) in Ada'a and Lume districts of East Shewa, respectively. It was also slightly higher than 41.02, 40.86 and 43±10.9 years reported by Solomon *et al*. (2013), Moges *et al*. (2013) and Worku *et al*. (2012) in Metekel zone of Northwest Ethiopia, Bure district of North West and west Amhara region of Ethiopia, respectively.

The mean family size with age of less than 15 years (younger age) in the midland (2.29±1.58) was significantly ($P<0.05$) higher than from lowland (1.93±1.31) but not from highland agro-ecology (2.22±1.37). The mean family size in the age category (≥15 and ≤ 60 years) was not significantly different among the agro-ecological zones of study area. The mean family size in the older age category (> 60 years) in midland (0.26±0.97) did not statistically different from low land (0.13±0.39) but significantly greater than the highland agro-ecology (0.04±0.25). Overall, the average family size in the younger age (<15 years age), productive age category (≥15 and ≤60 years age) and older age category (>60 years) was 2.12±1.43, 3.79±2.00 and 0.15±0.64, respectively in the study area. This implies the family size of productive age category is greater than the unproductive age categories. It will serve as an important input which creates a room for success of designing and implementation of sustainable poultry genetic improvement programs and to adoption of improved technologies in general.

Regardless of the age category, the mean of total family size in the midland agro-ecology was 6.40±2.55 which was significantly different from lowland (5.67±2.12) but not from highland agro-ecology (6.06±2.38) (Table 7). In general, the overall mean of the family size in the study area was 6.01±2.35. This result was higher than the average family size (4.02) per household, reported by Solomon *et al*. (2013) in Metekel zone of Northwest Ethiopia but comparable with the findings of both Worku *et al*. (2012) and Moges *et al*. (2013) who reported that the family size of 6.0±2.00 and 6.19±2.17 in West Amhara region and Bure district of North West Ethiopia, respectively.

Pertaining to livestock holding, the average number of cows per household in lowland agro-ecology was 6.39±5.51 which was significantly higher than from the highland (2.09±1.46) but not from the midland agro-ecology (6.26±5.51). However, the mean number of oxen per household in the lowland agrology (1.43±1.23) was significantly lower than from both midland (1.94±1.129) and highland (1.86±1.00) agro-ecologies (Table 7). This might be due to the variability in land cultivation methods practiced among farmers residing in different agro-ecologies. It was found that almost all farmers used tractor to cultivate their land and occasionally used machines for threshing of sorghum and they are not interested to keep more than one oxen with their herd in the lowland agro-ecology. In addition to this, farmers with more than two oxen and/or steers, they usually select one steer or ox for breeding purpose and sell the remaining ones in the lowland agro-ecology. Whereas farmers are usually interested to keep more than one ox since they use oxen to cultivate their land and for cereal crops threshing purposes in both midland and highland agro-ecologies.

The result also revealed that the average number of heifers, steers, calves and total cattle per household were significantly different among the agro-ecological zones. The average number of heifers steers and calves per household in the lowland agro-ecology (3.74±2.53, 1.04±1.01 2.02±1.24 and 14.63±9.55, respectively) were significantly higher than from both midland and highland agro-ecologies. Overall, the mean number of cows, oxen, heifers, steers, calves and total cattle per household were 5.30±511, 1.71±1.16, 2.64±2.19, 0.81±0.85, 1.47±1.22 and 11.93±8.67, respectively in the study area. This result was much higher than from the research findings of Moges *et al*. (2013) who reported the mean number of cows, oxen, heifers and steers, calves and the mean of total cattle per household were 0.99, 1.73, 0.62, 0.81 and 4.16 ±3.6, respectively in Bure district of North West Ethiopia.

Regarding with number of goats per household, the mean number of doe, young female ,kids and total number of goats per household in the lowland agro-ecology (9.87±8.38, 5.40±4.33 ,3.09±2.62 and 20.64±16.81, respectively) were significantly higher than midland (7.80±5.40, 3.73±2.51, 2.45±1.79 and 16.23±10.37, respectively) and highland (3.01±3.46,1 .49±1.69 ,1.13±1.42 and 6.68±7.63, respectively) (Table 7).

The mean number of young male goats and buck per household in the lowland agro-ecology was significantly greater than from highland but not from midland agro-ecology. In general, the mean total number of doe, buck, young female goat, young male goat, kids and total number of goats per household were 7.50±7.00, 0.68±0.78, 3.88±3.60, 1.30±1.40, 2.39±2.34 and 15.73±14.06, respectively (Table 7).

Likewise, the average number of ewe, young female sheep, young male sheep, lamb and total number of sheep per household in lowland agro-ecology were significantly higher than both midland and highland agro-ecologies but there was no significant difference between midland and highland agro-ecology. The mean number of ram per household in the lowland was significantly higher than midland agro-ecology but not from highland agro-ecology. Overall, the mean number of ewe, ram, young female sheep, young male sheep, lamb and total number of sheep were 3.41±7.11, 0.34±0.70, 1.623±3.39, 0.6±1.1, 1.2±2.1 and 7.13±13.52, respectively in the study area. The mean number of donkey per household in highland agro-ecology (1.56±1.25) was significantly higher than from midland (0.95±0.99) but not from lowland (1.19±1.28) (Table 7). The average number of donkey per household in the study area was 1.2±1.2. This result was much higher than from the findings of Moges *et al*. (2013) who reported the mean number of donkey per household to be 0.54 in Bure district of North West Ethiopia. This might be due to people often use donkeys as cart for transporting water, Cement and other construction materials in addition to accomplishing their daily farming activities because most donkeys of the area particularly in the lowland are large sized donkeys called 'Sinnar'.

Pertaining to cultivated land size (hectare), the average total cultivated land and own cultivated land per household in lowland agro-ecology were significantly greater than both midland and highland agro-ecologies but no significant variation was observed between midland and highland agroecology. However, there was no significant variation with respect to average rent cultivated land size per household across the three agro-ecologies of the zone. Generally, the total own, rent and total cultivated land per household were 6.24±15, 6.93±10.14 and 13.15±20.9, respectively in the study area. This result was higher than 1.28 hectare and 1.23±1.23 hectare reported by Halima (2007) and Moges *et al.* (2013) in North

West Amhara region and Bure district of North West Ethiopia, respectively. Likewise, it was also higher than the national average landholding /household of 1.02 hectare (EEA, 2002).

Table 7: Socio-economic characteristics of households in the agro-ecologies of the study area

parameters	Agro-ecological zones			
	highland mean ± SD	midland mean ± SD	lowland mean ± SD	Overall mean ±SD
Age (years)	42.95±10.82[b]	47.92±12.09[a]	47.46±12.35[a]	46.51±12.05
family size				
≤14 years	2.22±1.37[ab]	2.29±1.58[a]	1.93±1.31[b]	2.12±1.43
≥15 and ≤ 60	3.81±2.09[a]	4.02±2.20[a]	3.59±1.75[a]	3.79±2.00
> 60 years	0.04±o.25[b]	0.26±0.97[a]	0.13±0.39[ab]	0.15±0.64
Total	6.06±2.38[ab]	6.40±2.55[a]	5.67±2.12[b]	6.01±2.35
livestock holdings				
Cattle				
Cow	2.09±1.46[b]	6.26±5.51[a]	6.39±5.51[a]	5.30±5.17
Ox	1.86±1.00[a]	1.94±1.12[a]	1.43±1.23[b]	1.71±1.16
Heifers	1.26±0.79[c]	2.30±1.68[b]	3.74±2.53[a]	2.64±2.19
Steers	0.44± 0.52[c]	0.79±0.82[b]	1.04±1.01[a]	0.81±0.85
Calves	0.63±0.66[c]	1.41±1.16[b]	2.02±1.24[a]	1.47±1.22
Total	6.27±3.66[c]	12.70±8.26[b]	14.63±9.55[a]	11.93±8.67
Goat				
Doe (>6mth)	3.01±3.46[c]	7.80±5.40[b]	9.87±8.38[a]	7.50±7.00
Buck(> 6mth)	0.39±0.66[b]	0.78±0.74[a]	0.74±0.86[a]	0.68±0.78
Young female(3- 6 mth)	1.49±1.69[c]	3.73±2.51[b]	5.40±4.33 [a]	3.88±3.60
Young male (3-6mth)	0.66±0.92[b]	1.47±1.22[a]	1.55±1.64[a]	1.30±1.40
Kid (<3 mth)	1.13±1.42[c]	2.45±1.79[b]	3.09±2.62[a]	2.39±2.34
Total	6.68±7.63[c]	16.23±10.37[b]	20.64±16.81[a]	15.73±14.06
Sheep				
Ewe ((>6mth)	2.4±0.40[b]	1.91±4.30[b]	5.21±0.7[a]	3.41±7.11
Ram ((>6mth)	0.35±0.50[ab]	0.22±0.47[b]	0.44±0.99[a]	0.34±0.74
Young female(3- 6 mth)	1.287±1.81[b]	1.02±2.25[b]	2.32±4.6[a]	1.623±3.39
Young male(3- 6 mth)	0.5±0.799[b]	0.4±0.73[b]	0.86±16.81[a]	0.6±1.10
Lamb(<3 mth)	0.8±1.20[b]	0.7±1.60[b]	1.8±2.6[a]	1.2±2.10
Total	5.4±1.40[b]	4.2±1.20[b]	10.6±1.05[a]	7.13±13.52
Donkey	1.56±1.25[a]	0.95±0.99[b]	1.19±1.28[ab]	1.2±1.20
Cultivated land (hectare)				
own	2.92±2.05[b]	3.59±4.5[b]	10.4±23.6[a]	6.24±15.90
rent	5.2±3.02[a]	7.32±12.4[a]	7.66±10.7[a]	6.93±10.14
total	8.08±3.55[b]	10.8±15.7[b]	18.04±28.5[a]	13.15±20.9

Values with different letters are significantly different ($p<0.05$)

4.2. Production Systems

4.2.1. General production description

The analysis of farming system showed that 97.7% of the total respondents practiced mixed farming (crop and livestock production) system whereas the remaining 2.1% and 0.3% of the respondents practiced sole livestock and sole crop production systems, respectively in the study area (Table 8). The proportions of respondents practicing mixed crop and livestock, sole livestock and sole crop production systems were not different among the agro-ecologies. The result of the survey revealed that mixed grazing (97.1%) was the most predominant grazing pattern while zero grazing (0.3%) was the least frequent practiced grazing pattern in the study area. The proportions of respondents who practiced free, zero and mixed grazing patterns had not differed among the agro-ecologies. Nevertheless, zero- grazing was only practiced by 0.6% of the respondents in the lowland agro-ecology but none of the respondents had practiced zero-grazing pattern in both highland and midland agro-ecologies.

The analysis of the main crops produced revealed that 47.5% of the total interviewed households mainly produced sesame (1^{st}) & sorghum (2^{nd}) (low land), barley (1^{st}), wheat (2^{nd}), teff (3^{rd}), maize (4^{th}), finger millet (5^{th}), fababeans (6^{th}), chickpeas (7^{th}), noug (8^{th}), rice and lentils (9^{th}) (highland & midland) (Table 8). The proportions of respondents producing different cereal crops varied from agro-ecology to agro-ecology. This could be due to the differences in the climatic suitability of different cereal crops across the agro-ecologies as the agro-ecological variables (rain fall, temperature, humidity, soil fertility and others) varied among agro-ecologies. Higher proportions of respondents produced sesame (1^{st}), sorghum (2^{nd}) & maize (3^{rd}) in the lowland agro-ecology (55%) than in both midland and highland agro-ecologies. whereas 78.7% and 83.2% of respondents produced sesame (1^{st}) & sorghum (2^{nd}) (low land), barley (1^{st}), wheat (2^{nd}), teff (3^{rd}), maize (4^{th}), finger millet (5^{th}), fababeans (6^{th}), chickpeas (7^{th}), noug (8^{th}), rice & lentils (9^{th}) (highland & midland), respectively in highland and lowland agro-ecologies.

Table 8: General production system (% of respondents)

Variable	Agro-ecological zones				X^2-test	p-value
	High altitude (n =94)	Mid altitude (n=131)	Low altitude (n=160)	Total (N=385)		
Farming system					4.859(ns)	0.088
Crop production	-	1(0.8)	-	1(0.3)		
Livestock production	4(4.3)	4(3.1)	-	8(2.1)		
Crop & livestock production	90(95.7)	126(96.2)	160(100)	376(97.7)		
Grazing pattern					2.625(ns)	0.269
Free grazing	4(4.3)	5(3.8)	1(0.6)	10(2.6)		
Zero grazing	-	-	1(0.6)	1(0.3)		
Mixed grazing	90(95.7)	126(96.2)	158(98.8)	374(97.1)		
Main Crops produced in the area					36.67(*)	0.000
Sorghum (1st), sesame (2nd), maize (3rd) & finger millet (4th)	1(1.1)	-	2(1.2)	3(0.8)		
Sesame (1st),sorghum (2nd),maize (3rd) & *Bultug* (4th)	-	1(0.8)	10(6.2)	11(2.9)		
Sesame, sorghum and maize (rain fed cultivation) & lemon, orange, mango, Apple, *Kok* (*Zeytihun*), chat (irrigated land)	-	-	1(0.6)	1(0.3)		
Sesame (1st), sorghum (2nd), maize (3rd), barley (4th),wheat (5th), noug(6th) & finger millet (7th), teff (8th)	-	1(0.8)	-	1(0.3)		
Sesame(1st) , sorghum (2nd), maize (3rd), *Bultug* (4th) & rice (5th)	-	-	1(0.6)	1(0.3)		
Sorghum, finger millet, maize, teff, chickpeas, fababeans, noug, lentils, wheat, barley	6(6.4)	2(1.5)	-	8(2.1)		

*(p<0.05) & ns (p>0.05) at p (0.05) and n = number of households interviewed

Table 8 (continued)

Variable	Agro-ecological zones				X^2-test	p-value
	High altitude (n =94)	Mid altitude (n=131)	Low altitude (n=160)	Total (N=385)		
Teff, barley, wheat, fababeans, chickpeas, noug, lentils, maize	1(1.1)	2(1.5)	-	3(0.8)		
Teff, barley, wheat, maize, fababean, lentils, noug, chickpeas	1(1.1)	-	-	1(0.3)		
Sesame (1st) & sorghum (2nd) (low land), barley (1st), wheat (2nd), teff (3rd) , maize (4th), finger millet (5th), fababeans (6th), chickpeas (7th), noug (8th), rice & lentils (9th) (midland & highland)	74(78.7)	109(83.2)	-	183(47.5)		
Sesame (1st), sorghum (2nd), maize (3rd) & finger millet (4th) (low land); barley, wheat, teff, fababean, chickpeas, noug & lentils (highland)	7(7.4)	-	-	7(1.8)		
Sesame (1st), sorghum (2nd) & maize (3rd)	-	10(7.6)	88(55)	98(25.5)		
Sesame, sorghum, soybean & maize	-	-	3(1.9)	3(0.8)		
Sesame, sorghum, maize, green gram & pepper	-	-	1(0.6)	1(0.3)		
Sesame (1st), sorghum (2nd), maize (3rd), finger millet (4th), teff (5th)	-	1(0.8)	34(21.2)	35(9.1)		
Sesame (1st) and sorghum (2nd)	-	-	19(11.9)	19(4.9)		
Sesame, sorghum, finger millet, Teff, maize, banana & papaya	-	-	1(0.6)	1(0.3)		

*($p<0.05$) & ns ($p>0.05$) at p (0.05) and n = number of households interviewed

4.2.1.1. Livestock ownership and role of household members

The analysis of the ownership of livestock species revealed that the proportions of women and men owning cattle, small ruminant and poultry differed among the agro-ecologies but the ownership of equines were not significantly different across agro-ecologies (Table 9). Overall, 88.1% of the total respondents had cattle while the remaining 11.9% of respondents had no cattle. The respondents with cattle replied that men (40.5%) had the highest right to own cattle and followed by both women and men (35.6%) while women (11.9%) had the least right to own cattle in the study area. Likewise, 79.5% of the total interviewed households had small ruminant whereas the rest 20.5% of the respondents had no small ruminant. The respondents responded that men (37.1%) had the highest right to own small ruminant in the family member while women had the least right to own small ruminant in a given family. However, the respondents replied that both men and women (76.9%) had the first rank right to own poultry while men (1) % had the least right to own poultry. Women (22.1%) had much greater right to own poultry than men (1%) within a given family member.

The proportions of men and women owning equines had not differed among the agro-ecologies of the study area. The survey result indicated that 71.2% of the total respondents had equines whereas the remaining 28.8% had no equines in the study area. Generally, the respondents replied that equines were predominantly owned by men (34%) followed by both women and men (28.8%) and women (8.4%) in the study area.

The survey result revealed that all family members had participated in livestock management activities even if the degree of involvement of the family members in all management aspects varied in the study areas (Appendix table 1). The respondents indicated that both men and male children had the highest responsibility of taking care of cattle (56.9%), small ruminants (53.8%) and equines (48.3%) while men, women and female children had the least responsibility of managing both cattle (0.3%) and equine (0.5%) and men, women and male children had the least responsibility of taking cares of small ruminants (0.3%) in the study area. In contrast, women and female children were the predominant poultry (59%) care takers of the family members and followed by women (39.5%), and men and male children (0.3%) were the least responsible family members of taking cares of poultry in the study area.

Table 9: Livestock ownership of household family members in three agro-ecological zones of Western Tigray

Livestock species	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Cattle					13.64(*)	0.001
Men	40(42.6)	68(51.9)	48(30)	156(40.5)		
Women	10(10.6)	12(9.2)	24(15)	46(11.9)		
both	31(33)	43(32.8)	63(39.4)	137(35.6)		
No cattle	13(13.8)	8(6.1)	25(15.6)	46(11.9)		
Small ruminant					26.86(*)	0.000
Men	32(34)	67(51.1)	44(27.5)	143(37.1)		
Women	9(9.6)	13(9.9)	18(11.2)	40(10.4)		
both	28(29.8)	43(32.8)	52(32.5)	123(31.9)		
No small ruminants	25(26.6)	8(6.1)	46(28.8)	79(20.5)		
Equines					5.739(ns)	0.057
Men	32(34)	55(42)	44(27.5)	131(34)		
Women	7(7.4)	8(6.1)	17(10.6)	32(8.4)		
both	21(22.3)	38(29)	52(32.5)	111(28.8)		
No equines	34(36.2)	30(22.9)	47(29.3)	111(28.8)		
Poultry					11.637(*)	0.003
Men	0(0)	2(1.5)	2(1.2)	4(1)		
Women	16(17)	20(15.3)	49(3.6)	85(22.1)		
both	78(83)	109(83.2)	109(68.1)	296(76.9)		

*(P<0.05) & ns (P<0.05) at p (0.05) and n = number of households interviewed

4.2.2. Poultry production system

4.2.2.1. Flock composition and size

The result of the survey revealed that the mean indigenous layers, cockerel, pullets and total indigenous flock size per household in the lowland agro-ecology was significantly higher than both other agro-ecologies but no significant variation was observed between midland and highland agro-ecologies (Table 10). However, the mean indigenous cock and chicks per household did not differ significantly among the agro-ecological zones. Overall, the average indigenous layers, cock, cockerel, pullet, chicks and total indigenous flock size per household were 5.50±3.50, 0.75±0.67, 2.51±1.82, 5.67±3.52, 8.41±5.09 and 22.83±10.60, respectively in the study area. This result was higher than the mean chicken flock size/household of 6.23±4.4 (ranged 1-16); 13.68±0.62 and 13.1±10 (ranged 1-57) reported by Meseret (2010) in Gomma wereda of Jimma zone and Solomon *et al*. (2013) in Metekel zone of Northwest Ethiopia and Moges *et al*. (2013) in Bure district of North West Ethiopia, respectively.

Regarding to the mean exotic chicken flock size /household, the mean exotic layers per household in midland (0.50±0.76) was significantly greater than both highland (0.30±0.60) and lowland (0.27±0.53) but not significantly different between lowland and highland agro-ecologies. However, the mean exotic pullet and cockerel per household in the lowland agro-ecology (0.33±0.64) was significantly higher than midland (0.18±0.48) and highland (0.15±0.39) but not significantly different between midland and highland agro-ecological zones. Significantly higher mean exotic chicks per household were obtained in highland agro-ecology (0.23±0.65) than midland (0.07±0.35) and lowland (0.03±0.22) agro-ecologies. Similarly, significantly greater mean exotic cockerel per household was obtained in highland (0.22±0.66) than lowland (0.10±0.34) but statistically similar with midland (0.15±0.43).
The mean exotic cock and total exotic flock size per household were not significantly different among the three agro-ecological zones. Overall, the mean exotic layers, cock, cockerel, pullets, chicks and total exotic flock size per household were 0.36±0.64, 0.14±0.36, 0.15±0.47, 0.24±0.54, 0.09±0.41 and 0.96±0.76, respectively the study area. This could be

attributed to the exotic breeds' adaptability difference in response to different environmental factors across the agro- ecologies.

Pertaining to the mean Crossbred chickens flock size per household, the mean crossbred layers, cockerel, pullet and total crossbred flock size per household were not significantly different among the agro-ecological zones. However, significantly lower mean crossbred cock per household was obtained from lowland agro-ecology (0.01±0.11) than midland (0.10±0.30) and highland (0.12±0.32) but not differed between highland and midland agro-ecological zones. In contrast, significantly higher mean crossbred chicks size per household was obtained in lowland agro-ecology (1.08±0.91) than midland (0.79±0.94) but statistically similar with highland agro-ecology (0.91±1.07). Generally, the mean crossbred layers, cock, cockerel, pullets, chicks and total crossbred flock size per household were 0.15±0.46, 0.07±0.25, 0.15±0.53, 0.26±0.58, 0.94±0.97 and 1.57±2.19, respectively in the study area.

Regardless of the breed of chickens, the survey revealed that the overall mean of layers, cock, cockerel, pullets, chicks and total flock size were 6.00±3.60, 0.95±0.75, 2.81±1.97, 6.17±3.59, 9.44±4.95 and 24.35±10.69, respectively in the study area (Table 10). This indicates the household may have a mix of chicken genotypes which in turn creates widen opportunity for unplanned /indiscriminate cross breeding to be existed among the flock. Indiscriminate cross breeding is the major threat to the adapted indigenous livestock breeds through breed replacement (Halima, 2007; Kefyalew, 2013). Maintenance of well adapted indigenous chicken gene pool diversity is very crucial to fulfill the present and future market demands, to serve as an insurance against environmental changes such as changes in production circumstances, socio-economic, historic and cultural as well as to provide adequate genetic material sources for ensuring sustainable utilization and improvement. Moreover, village chicken flocks scavenge together and interbreed among themselves in the study area and some breeding cocks are more dominant and aggressive than others. These situations will increase the chance of consecutive interbreeding among more related chickens which in turn increases the incidence of inbreeding. Rotational mating is effective system to reduce the short and long term inbreeding effect of animals irrespective of the effective population size of the animals (Takeshi *et al*., 2004; Okeno *et al*., 2010).

Therefore, farmers need to be encouraged to avoid mating of closely related individuals among their chicken flocks through keeping breeding cocks and exchanging them with other farmers located further than the scavenging distance.

Community based and environmentally friendly holistic genetic improvements programs should be designed and implemented so as to conserve, to utilize and improve sustainably well adapted indigenous chicken genetic resources. Lwelamira *et al*. (2008) reported that Selection breeding programs of 5 to 10 generations of selection (3 to 6 years of selection) was successful for improving the population mean of Tanzanian indigenous chicken ectypes' body weight under village conditions from 974 gram to 1300 gram. Controlled and monitored cross breeding with appropriate records and improved managements can be used as last option for genetic breeding program in the indigenous genetic resources after checking the lacking traits in the local chicken ecotypes are not improved by selection. Because exotic germplasms have been introduced for cross breeding with the focus of immediate financial returns from specific performance traits improvements (egg yield or growth) but result in unforeseen substitution of indigenous genes by exotic genes which gradually leads to complete replacement of indigenous genetic resources (Kosgey, 2004; kefyalew, 2013). On-farm or community-based conservation (in-situ conservation) of indigenous chicken genetic resources is highly recommended to be implemented because it enables the sustainable use of the indigenous chicken ecotypes with the participation of chicken producers in their original production environments without the application of sophisticated modern reproductive technologies.

Table 10: Chicken flock structures & sizes of indigenous, exotic & cross bred chickens in three agro-ecological zones of Western Tigray

parameters	highland (Mean±SD)	Midland(Mean± SD)	Lowland(Mean± SD)	Overall(Mean± SD)
Indigenous chickens				
hen/layers	4.26±2.74[b]	4.88±3.01[b]	6.73±3.87[a]	5.50±3.50
cock ((>20 wks)	0.8±0.60[a]	0.8±0.61[a]	0.68±0.74[a]	0.75±0.67
Cockerel(8-20 wks)	2.05±1.67[b]	2.4±1.90[b]	2.88±1.78[a]	2.51±1.82
Pullet(8-20 wks)	4.69±2.73[b]	5.36±3.10[b]	6.50±4.06[a]	5.67±3.52
Chicks(0-8 wks)	8.07±4.71[a]	7.92±4.67[a]	9.0±5.57[a]	8.41±5.09
Total	19.87±8.20[b]	21.36±9.68[b]	25.78±11.82[a]	22.83±10.60
Exotic chickens				
hen/layers	0.30±0.60[b]	0.50±0.76[a]	0.27±0.53[b]	0.36±0.64
cock (>20 wks)	0.11±0.31[a]	0.11±0.34[a]	0.17±0.39[a]	0.14±0.36
Cockerel(8-20 wks)	0.22±0.66[a]	0.15±0.43[ab]	0.10±0.34[b]	0.15±0.47
Pullet(8-20 wks)	0.15±0.39[b]	0.18±0.48[b]	0.33±0.64[a]	0.24±0.54
Chicks(0-8 wks)	0.23±0.65[a]	0.07±0.35[b]	0.03±0.22[b]	0.09±0.41
Total	1.01±2.24[a]	1.02±1.80[a]	0.89 ±1.37[a]	0.96±1.76
Crossbred chickens				
hen/layers	0.21±0.60[a]	0.14±0.43[a]	0.13±0.39[a]	0.15±0.46
cock ((>20 wks)	0.12±0.32[a]	0.10±0.30[a]	0.01±0.11[b]	0.07±0.25
Cockerel(8-20 wks)	0.15±0.59[a]	0.18±0.65[a]	0.11±0.35[a]	0.15±0.53
Pullet(8-20 wks)	0.30±0.72[a]	0.27±0.63[a]	0.23±0.43[a]	0.26±0.58
Chicks(0-8 wks)	0.91±1.07[ab]	0.79±0.94[b]	1.08±0.91[a]	0.94±0.97
Total	1.69±2.64[a]	1.49±2.43[a]	1.56±1.65[a]	1.57±2.19
Total chickens				
hen/layers	4.73±2.88[b]	5.52±3.09[b]	7.13±4.02[a]	6.00±3.60
cock ((>20 wks)	1.02±0.73[a]	1.02±0.71[a]	0.86±0.79[a]	0.95±0.75
Cockerel(8-20 wks)	2.43±1.79[b]	2.73±2.12[b]	3.09±1.92[a]	2.81±1.97
Pullet(8-20 wks)	5.14±2.86[b]	5.82±2.96[b]	7.06±4.20[a]	6.17±3.59
Chicks(0-8 wks)	9.22±4.72[b]	8.78±4.65[b]	10.11±5.26[a]	9.44±4.95
Total	21.63±8.32[b]	22.89±9.51[b]	27.16±12.14[a]	24.35±10.69

Values with different letters with same row are significantly different ($p<0.05$)

NB: wks=weeks

4.2.2.2. Ownership and gender role in poultry production

Every family member participated in taking cares of chickens even if their degrees of responsibilities varied among family members. The responsibility share of family members in providing feed and water, cleaning chicken houses, selling chickens and eggs and purchasing drugs (treatments) were not different among the agro-ecologies (Table 11).There was significant variation in the responsibility share of family members with regard to poultry house/shelter/ construction across agro-ecologies. Overall, the result of the survey revealed that 59.5% of the respondents constructed poultry shelter while 40.5% of them did not construct chicken shelter. Sole women and sole men (28.6%) had equal share of responsibilities with respect to chicken shelter construction while 1.3% of chicken shelter constructed in common with different division of activity where men are involved in arrangement of wood and finalization of houses with mud was the responsibility of women. The male children had the least responsibility in chicken shelter construction in the study area. Men had higher responsibility in chicken shelter construction in lowland agro-ecology (41.9%) than highlands (22.3%) and midland (16.8%) agro-ecologies while women had greater responsibility in midland (38.9%) than in highlands (34%) and lowland (16.9%) agro-ecologies. However, contrasting results have been reported from Lowland and midland agro-ecological zones of centeral Tigray as reported by Alem *et al*. (2014) who revealed men's highest responsibilities in chicken house construction (100%) in male headed households.

The same author also reported that chicken house was constructed by women (52.4%, 51.9%) followed by eldest male youth (33.3%%, 29.6%) and paid laborer (14.3%, 18.5%) in female headed households in lowland and midland agro-ecological zones of centeral Tigray, respectively. Samson & Endalew (2010) had also reported that men (57.5%) had the highest share of chicken house construction followed by children accounting for 30% in the mid Rift valley of Oromia. Men were mainly involved in chicken shelter construction in Fogera wereda (63.9%) (Bogale, 2008) and in Bure district of Amhara regional state (97.5%) (Fisseha, 2009). Mengesha *et al*. (2008) reported that men (65.3%) took the highest share of chicken house construction followed by women (19.6%) and children (15.1%) in Jamma district of South Wollo zone of Ethiopia.

Overall, both women and female children (56.6%) accounted the maximum share in offering feed and water for chickens followed by women (42.1%), female children (0.5%), female children and men (0.5%) and men and male children (0.3%). This result was close to the ones reported by Bogale (2008) that women (59.72%) were mainly involved in providing feeds and water for chickens in Fogera district of Amhara regional state. Nevertheless, it was lesser than the results reported from Bure district (80.7%) (Bogale, 2008), Jamma district of South Wollo (84.5%) (Mengesha *et al*., 2008), Metema district (feeding (73.3%) and watering (72%) (Hassen *et al*., 2012), and lowland and midland agro-ecologies of Centeral Tigray (67.5% and 65.5%, and 77.7% and 77.5%) in male headed and female headed households, respectively (Alem *et al.*, 2014).

Likewise, both women and female children, and women had the first and second major responsibilities of cleaning chicken house (56.9% and 41.8%), selling chickens (54.5% and 43.1%) and selling eggs (54.5% and 42.9%), respectively in the study area. The responsibility share of women for cleaning chicken house obtained in this study was lower than from the results (62.5%) reported from Fogera district (Bogale, 2008), 91% from Gomma wereda of Jimma zone (Meseret *etal,* 2011), 69.33% from Metema district of Amhara regional state (Hassen *et al*., 2012), 82.5% from Jamma district of South Wollo (Mengesha *et al*., 2008) and 82.5% and 70% of male headed households, and 80% and 82.5 % of female headed households from low land and midland agro-ecologies of Centeral Tigray, respectively. It was, however, higher than 38.6% reported from Bure district (Fisseha, 2009).

The survey indicated both women and female children, and sole women took the highest share of responsibilities in selling chickens (54.5% and 43.1%, respectively) and selling eggs (54.5% and 42.9 %, respectively). Similarly, previous findings also revealed that selling chickens (56.95% and 82.95%) and selling eggs (63.89% and 54.6%) were practiced by women in Fogera (Bogale, 2008) and Bure (Fisseha *et al*., 2009) districts of Amhara regional states, respectively. In this study it was noted that men (79.7%) had the highest share of responsibilities for purchasing drugs / treatment for chickens followed by women (16.6%), male children (1.6%) and, women and female children (0.5%). This result was in line with the results reported from male headed households of Centeral Zone of Tigray that 62.5% and 80%

of purchasing drugs was accomplished by men in lowland and midland agro-ecologies, respectively (Alem *et al.*, 2014). Similarly, Fisseha (2009) reported that men (89.3%) had the greatest share of responsibilities for treating chickens (purchasing drugs or treatment) in Bure district of Amhara regional state.

The analysis of decision making of household members indicated that the proportions of household members with respect to making decisions in eggs selling, home consumption and purchasing eggs did not differ across the agro-ecologies ($p>0.05$) (Table 12). However, the decision making share of the household members for chicken selling and home consumption, chicken purchasing and chicken products as gift were significantly varied among the three agro-ecologies ($p\leq0.05$). In general, 99% of the total interviewed households had practiced both selling eggs and chickens but the remaining 1% of the respondents had not. The result of the study revealed that Women had the greatest share to decide on eggs for selling (97.4%), eggs for home consumption (98.7%), chicken selling (93.5%), purchase of eggs (98.7%) and purchase of chickens in the study area. On the other hand, decisions on chickens for home consumption (76.1%) and offering chicken product as a gift (76.4%) were accomplished by men and women in common while men had the major decision role for purchasing drugs /treatment (70.6%). It implies that women had greatest decision making share in poultry product utilization as compared to men. Understanding of the labor and ownership profiles as well as gender role has a bearing effect on the success of designing and implementation of sustainable poultry breeding programs. This result was similar with the reports of Alem *et al*. (2014) who confirmed that women in the female –headed households were responsible for decision making on selling eggs (80% and 70%), selling chickens (82.5% and 72.5%), home consumption of eggs (77.5% and 70%), consumption of chickens (100% and 97.5%), purchase of drugs (100% and 100%) and purchase of chickens (100% and 100%) in lowland and midland agro-ecology of central Tigray, respectively. The same author also reported that men had the major decision role on purchasing drugs/ treatments in both lowland (77.5%) and midland (82.5%) while home consumption of chickens(62.5% and 97.5%) was accomplished by the common decisions of both men and women in midland and lowland agro-ecologies of central zones in male headed households.

Table 11: Labor division of household members in poultry management in the three agro-ecological zones of western Tigray

Activities	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Shelter construction					6.913(*)	0.032
Men	21(22.3)	22(16.8)	67(41.9)	110(28.6)		
Women	32(34)	51(38.9)	27(16.9)	110(28.6)		
Men & women (arrangement of wood by men ,& finalization of house with mud by women)	1(1.1)	3(2.3)	1(0.6)	5(1.3)		
Male children	-	2(1.5)	2(1.2)	4(1)		
No shelter	40(42.6)	53(40.5)	63(39.4)	156(40.5)		
Providing feed & water					7.775(*)	0.020
Women	40(42.6)	44(33.6)	78(48.8)	162(42.1)		
Female children	-	-	2(1.2)	2(0.5)		
Women & female children	54(57.4)	85(64.9)	79(49.4)	218(56.6)		
Men & female children	-	2(1.5)	-	2(0.5)		
Men & male children	-	-	1(0.6)	1(0.3)		
Cleaning chicken house					5.219(ns)	0.074
Women	40(42.6)	44(33.6)	77(48.1)	161(41.8)		
Men	-	1(0.8)	-	1(0.3)		
Female children	-	1(0.8)	2(1.2)	3(0.8)		
Women & female children	54(57.4)	85(64.9)	80(50)	219(56.9)		
Men & male children	-	-	1(0.6)	1(0.3)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed.

Table 11 (Continued)

Activities	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Selling chicken					7.449(*)	0.024
Women	40(42.6)	45(34.4)	81(50.6)	168(43.1)		
Female children	-	1(0.8)	2(1.2)	3(0.8)		
Women & female children	54(57.4)	82(62.6)	74(46.2)	210(54.5)		
Men &male children	-	-	1(0.6)	1(0.3)		
No sell	-	3(2.3)	2(1.2)	5(1.3)		
Selling eggs					6.929(*)	0.031
Men	-	1(0.8)	1(0.6)	2(0.5)		
Women	40(42.6)	45(34.4)	80(50)	165(42.9)		
Female children	-	1(0.8)	2(1.2)	3(0.8)		
Women and female children	54(57.4)	82(62.6)	74(46.2)	210(54.5)		
men and male children	-	-	1(0.6)	1(0.3)		
No sell	-	2(1.5)	2(1.2)	4(1)		
Purchasing drugs / treatment					2.346 (ns)	0.309
Men	73(77.7)	110(84)	124(77.5)	307(79.7)		
Women	17(18.1)	17(13)	30(18.8)	64(16.6)		
Male children	2(2.1)	2(1.5)	2(1.2)	6(1.6)		
Women and female children	1(1.1)	-	1(0.6)	2(0.5)		
No purchase	1(1.1)	2(1.5)	3(1.9)	6(1.6)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed.

Table 12: Decision making share of household members in poultry product utilization in three agro-ecological Zones of western Tigray.

Activities	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Egg selling					1.451(ns)	0.484
Men	-	2(1.5)	3(1.9)	5(1.3)		
Women	94(100)	126(96.2)	155(96.9)	375(97.4)		
Men and women	-	1(0.8)	-	1(0.3)		
No sell	-	2(1.5)	2(1.2)	4(1)		
Chicken selling					2.048(ns)	0.359
Men	-	2(1.5)	12(7.5)	14(3.6)		
Women	94(100)	126(96.2)	140(87.5)	360(93.5)		
Men and women	-	1(0.8)	6(3.8)	7(1.8)		
No sell	-	2(1.5)	2(1.2)	4(1)		
Eggs for home consumption					1.700(ns)	0.427
Men	-	2(1.5)	3(1.9)	5(1.3)		
Women	94(100)	129(98.5)	157(98.1)	380(98.7)		
Chicken for home consumption					21.594(*)	0.000
Men	-	2(1.5)	19(11.9)	21(5.5)		
Women	14(14.9)	20(15.3)	37(23.1)	71(18.4)		
Men and women	80(85.1)	109(83.2)	104(65)	293(76.1)		
Purchase of drugs / treatment					8.745(*)	0.013
Men	65(69.1)	103(78.6)	104(65)	272(70.6)		
Women	15(16)	16(12.2)	37(23.1)	68(17.7)		
Men and women	-	-	3(1.9)	3(0.8)		
No purchase	14(14.9)	12(9.2)	16(10)	42(10.9)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed.

Table 12 (Continued)

Activities	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Purchase of eggs					1.700(ns)	0.427
Men	-	2(1.5)	3(1.9)	5(1.3)		
Women	94(100)	129(98.5)	157(98.1)	380(98.7)		
Purchase of chicken					4.372(ns)	0.112
Men	-	2(1.5)	3(1.9)	5(1.3)		
Women	94(100)	128(97.7)	148(92.5)	370(96.1)		
Men and women	-	1(0.8)	9(5.6)	10(2.6)		
Chicken products as gifted					22.121(*)	0.000
Men	-	2(1.5)	17(10.6)	19(4.9)		
Women	14(14.9)	19(14.5)	39(24.4)	72(18.7)		
Men and women	80(85.1)	110(84)	104(65)	294(76.4)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed

4.2.2.3. Feeding and feed resources

The result of the study indicated that 100% of the respondents practiced supplementary feeding on top of free scavenging (Table 13). This result was fairly similar with the results reported by Worku *et al*. (2013) from west Amhara of Ethiopia (100%), by Meseret (2010) from Gomma wereda of Jimma zone (97.8%), by Bogale (2008) from Fogera district of Amhara region (88.9%), by Halima (2007) from North West Ethiopia (99.28%), by Moges *et al.* (2010) from Bure district of North west Ethiopia (97.5%), by Hailu *et al*. (2012) from North west of Amhara regional state of Ethiopia (83.5%), by Tadesse *et al*. (2013) from both Ada'a and Lume districts of East Shewa (97.8%) and by Addisu *et al*. (2013) from North Wollo zone of Amhara regional state (89.87%). Comparable results have also been reported from five provinces of Cambodia that 94.7%, 100%, 95.8%, 87.2% and 97.7% of local chicken owners provided supplementary feeds in Kampongcham, Kampot, Odar meanchey, Rattanakiri and Siem Reap provinces of Cambodia (FAO, 2009a). The result confirmed that local chicken owners provide a feed sources such as sorghum (100%), maize (99.2%), sesame (65.2%), tomato (40.3%), onion (40%), barley (30.1%),Teff (28.3%), cabbages (24.9%),finge r millet (23.4%), noug (21.8%) , wheat (9.1%) and injera and bread (household food left over) (100%). Furthermore, maize (98.1%, 100% and 100%), sorghum (100%, 100% and 100%) and sesame (65.2%, 87.5% and 68.7) were the dominant supplementary feeds commonly supplied to chickens in lowland, midland and highland agro-ecologies, respectively. However, barley (38.9% and 69.1%), wheat (11.4% and 20.2%) and noug (40.5% and 33%) were only used as supplementary feeds in midland and highland agro-ecologies, respectively. Teff, finger millet, noug and grounded sorghum and maize were commonly offered for chicks (day old chicks up to one month age) that could not swallow large sized cereal crops without any mechanical treatment.

In a study conducted in East Shewa of Ethiopia by Tadesse *et al*. (2013) revealed that local chicken owners used wheat and maize (94.9%), kitchen waste (100%), wheat bran (1.7%) and limestone (2.2%) as chicken supplementary feeds. Likewise, Worku *et al*. (2012) reported that the types of grain used as supplementation varied across agro-ecologies and 50.4% of the households use maize as major sources of feed supplementation while 39.3% and 10.3% of them used wheat and barley, respectively in West Amhara region of Ethiopia. Meseret (2010) reported that maize (50.6%) and maize and sorghum (49.4%) were the major chicken grain supplementary feeds in Gomma wereda of Jimma zone. Addisu *et al*. (2013) also reported that local chicken owners used sorghum (36.7%), wheat (36.27%), maize (25.53%) and mixture (3.93%) as the predominant feed resources for their chickens in North Wollo zone of Amhara region. In the same way, Bogale (2008) also found that maize (75%), finger millet (70.83%), barley (22.22%), rice (19.44%), teff (13.89%), wheat (2.78%), sorghum (1.39%) and injera (16.67%) were used as chicken supplementary feeds in Fogera district.

Regarding to chicken feed resources, harvest (farm produced) was the main sources of cereal crops that could be used as chicken supplementary feeds while purchase (purchased from market) was the predominant sources of non-cereal feeds (like onion, tomato and cabbages leftover) in the study area (Table 13). This result was in parallel with the findings of Worku *et al*. (2012) that 87.2 % of the respondents used supplementary feeds produced from their own farm while 2.6% and 10.2% of them used purchased feeds and other sources in West Amhara region of Ethiopia. Similarly, 29.8%, 18.7%, 4.5%, 27.9% and 35.2% of those households providing supplementary feeds used purchased feeds as sources of chicken supplementary feeds in Kampongcham, Kampot, Odar meanchey, Rattanakiri and Siem Reap provinces of Cambodia (FAO, 2009a). The findings of the research accomplished in Gomma wereda of Jimma zone revealed that 62.8% of local chicken owners used grains from their own farm produced while 4.4% and 32.8% of them used feeds purchased from market and both farm produced and purchased, respectively (Meseret, 2010). Hence, in this study and literature review has demonstrated that, farmers diversify the feed resource base for chicken to ensure the sustainability of village based chicken production and contribute in the income and nutritional status as well as food security attainment of the community.

The times of offering supplementary feeds to chickens per a day practiced by local chicken owners are presented in Table 13. Three times a day (morning, afternoon and evening) (58.4%), twice (morning and evening) (20.5%), twice (morning and afternoon) (9.9%) and once (morning only) (8.1%) are the predominantly practiced feed supplementation times per a day in the study area.

This result was somewhat similar with the findings of Tadesse *et al*. (2013) that 78.9% of local chicken owners offered supplementary feeds to their chickens three times a day (morning, afternoon and evening) and 21.9% of them provided supplementary feeds two times a day in East Shewa of Ethiopia. Bogale (2008) also reported that 66.7% of local chicken owners offered feeds to their chickens one time (evening) and 45.83% of them provided feeds three times (morning, noon and afternoon) in Fogera district. However, contrasting results have been reported from North Wollo zone of Ethiopia that 37.9% of the households provided supplementary feeds two times per day (morning and evening) while 34.96% and 27.12% of them offered feeds to their chickens one times per day (morning or evening) and three times per day(morning, midday and evening), respectively (Addisu *et al.*, 2013). The findings of the study conducted in Gomma wereda of Jimma zone by Meseret (2010) revealed that 48.3% of households offered feeds to chickens two times per day (morning and afternoon), 22.2% of them provided feeds three times per day (morning, afternoon and evening) while 14.4%, 2.2%, 1.7%, and 1.1% of them offered one times (morning only), afternoon only, evening only and morning and evening, respectively. This implies that the perception of farmers towards proper feed supplementation of chickens improves chicken productivity (egg and meat yields) and health increases as time goes through acquired knowledge from their experiences and extension services. Thus, local chicken producers should be encouraged to offer diversified supplementary feed resources to chickens based on chicken age categories and their production levels in order to ensure sustainable improved chicken production thereby to attain food security of farmers and to reduce the likelihood illness of children through diversification of consumable foods.

Pertaining to frequency of feed supplementation per each feed offering time(s) in a day, the result of survey indicated that 98.7% of the respondents provided supplementary feeds to their chickens once while 1.3% of them offered feeds to chickens twice per morning of a given day (Table 14). Likewise, 30.1% and 18.4% of the total households interviewed did not offer supplementary feeds to chickens in the afternoon and evening of a given day, respectively. However, 69.6% and 81.35% of the households offered supplement feeds to chicks only once per the afternoon and evening of a day while 0.3% of them provided feeds to chicken twice per afternoon and evening of a day. This result was higher than the findings of Wondu *et al.*

(2013) revealed that 100%, 68% and 43% of the households provided only once per morning, afternoon and evening per a given day, respectively in Northern Gondar of Amhara regional state of Ethiopia.

Supplemental feeding was provided in three ways (Table 14). Overall, 94.8% of the households provided supplemental feeds for different age groups together (group feeding), 3.1% of the respondents offered feeds for different age classes separately and 2.1% of the households provided supplementary feeds to layers (hens) with their chicks. Most of the respondents supplied supplementary feeds to chickens on the ground (simply throwing the feed leveled ground) (97.8%) and the rest 2.1% of the respondents provided feeds to their chickens with local containers like plastic or metallic containers. This result was somewhat similar with the findings of Wondu *et al.* (2013) showed that provision of supplementary feeds was accomplished in two ways and 73% of the respondents offered feeds for different chicken age groups together and 27% of them provided feeds for different age classes separately in Northern Gondar of Amhara regional state. The same author also reported that 58% the respondents provided feeds to chickens on the ground and 42% of them used different old household utensils. Likewise, Meseret (2010) also reported that 97.2% of the households provided grain supplementary feeds for different chicken age groups together while 2.8% of them provided feeds for different age categories separately and 100% of households offered feeds to their chickens on the ground in Gomma wereda of Jimma zone. The findings of the study conducted in Fogera district revealed that 52.8% of chicken owners provided feeds for all classes together while 45.8% of them offered feeds for different classes separately to avoid competition among the different age groups of chickens, and 16.7% of households offered feeds to chickens on containers while 81.9% of them gave feeds to chickens on ground for collective feeding (Bogale, 2008). The present study and previous findings indicate that farmers usually offer supplementary feeds to their chickens on the ground for collective feeding regardless of chicken age categories and production levels. Moreover, local chicken producers do not aware of group feeding causes competition among different age categories of chicken that lead to cannibalism and cause more-dominant chicken to keep other away from feed and water which ultimately decreases chicken productivity and increases losses of chickens. Thus, farmers are highly recommended to provide their chickens with a well-balanced diet and an ample supply of water on separate basis of different age categories and chicken production levels in order to prevent cannibalism among their flock. Cannibalism has been linked to deficiencies in protein, sodium and phosphorus (Sheila & Sara, 2007). Therefore, local chicken producers are also strongly advised to adjust the protein requirement of chickens based on the recommended feeding schedule as the protein requirement changes as chicks grow. Otherwise, feed lacking protein and other nutrients particularly the amino acid Methionine will also cause birds to feather pecking (Sheila & Sara, 2007).

Basis of providing supplementary feeds had variation among agro-ecologies ($p<0.05$) (Table 15). Generally, the major objective of offering supplementary feeds were to increase both egg and meat yields and to maintain health status (90.6%) and to increase both meat and egg yields (6.2%). Likewise, Bogale (2008) reported that the predominant reasons of feed supplementation in Fogera district were to increase egg yield (9.23%) and increase both egg and meat yields (90.77%). The findings of research conducted in North Wollo zone of Amhara regional state revealed that the main objectives of feed supplementation of chicken owners were to increase egg yield (33.99%), to increase meat yield (34.97%) and maintain health (31.7%) (Addisu *et al.*, 2013).

There were significant variations with regard to season of extra feeding for chickens and improvements perceived due to feed supplementation across agro-ecologies of the study area (Table 15). Higher proportions of respondents in the lowland (63.1%) than in both highland (40.4%) and midland (37.4%) agro-ecologies indicated that season of critical supplemental feeding was dry season (winter) due to lack of feed to scavenge such as green feeds and worms while higher proportions of households in midland (61.8%) than in both highland (59.6%) and lowland (35%) indicated that season of critical extra feeding was summer (rainy season) owing to lack of grain supplements and households' food left over. Likewise, 1.9% of respondents in lowland perceived egg yield increment as a result of feed supplementation but none of the respondents in both midland and highland agro-ecologies perceived egg yield as sole improvement associated to supplementation. Higher proportions of households in the highland (18.1%) than in lowland (2.5%) and midland (0%) perceived both egg yield and growth improvement because of extra feeding while greater proportions of respondents in midland (100%) than lowland (95.6%) and highland (81.9%) perceived egg yield ,growth and health status improvements as a result of feed supplementation. Overall, the result indicated that 50.1% of total households interviewed said that season of critical extra feeding was rainy season (summer) owing to lack of supplement grains and households' food leftover (50.4%) while 48.8 % of respondents replied that season of critical supplementary feeding was dry season (winter) because of lack of feed to scavenge such as green feeds and worms (49.6%). Similarly, 93.8% of the total respondents perceived egg yield, growth & health statu s improvements as a result of feed supplementation while the remaining 5.5% and 0.8% of the respondents perceived both egg yield and growth, and sole egg yield improvements owing to supplementary feeding, respectively in the study area. In the same way, Bogale (2008) also found that 97.2% of the respondents replied that food shortage was critical during rainy (wet) season owing to scarcity of supplement grains, and 93.1% of the total households interviewed offered more supplementary feeds to their chicks in rainy (wet) season than dry seasons in Fogera district. Similar findings have also been reported by Samson & Endalew (2010) in mid rift valley of Oromia that revealed 95% of the respondents indicated that critical time of supplementary feeding was from June –August while the remaining 5% of them indicated that March – May was the critical time of feed supplementation. Hence, feed is a critical problem in both dry and wet season under village scavenging poultry production system that may necessitate persuading the farmers to practice strategic supplementation to increase meat and egg production thereby to attain food security.

Table 13: Feeding, feed resources and time of feed supplementation of chickens per day

Variable		Agro- ecological zones				X^2-test	p-value
		Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Supplementation over scavenging							
Yes		94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
No		-	-	-	-		
Feed types	Feed Sources						
Maize	harvest	88(93.6)	126(96.2)	152(95)	366(95.1)		
	Donation/gift	6(6.4)	5(3.8)	5(3.1)	16(4.2)		
	Total	94(100)	131(100)	157(98.1)	382(99.2)	1.567(ns)	0.457
sorghum	Harvest	87(92.6)	126(96.2)	160(100)	373(96.9)		
	Purchase	7(7.4)	5(3.8)	-	12(3.1)		
	Total	94(100)	131(100)	160(100)	385(100)	11.196(*)	0.004
Sesame	Harvest	21(22.3)	89(67.9)	140(87.5)	250(64.9)		
	Purchase	-	1(0.8)	-	1(0.3)		
	Total	21(22.3)	90(68.7)	140(87.5)	251(65.2)	1.796(ns)	0.407
barley	Harvest	63(67)	50(38.1)	-	113(29.4)		
	Purchase	2(2.1)	1(0.8)	-	3(0.8)		
	Total	65(69.1)	51(38.9)	-	116(30.1)	0.141(ns)	0.707
Wheat	Harvest	19(20.2)	15(11.4)	-	34(8.8)		
	Purchase	-	1(0.8)	-	1(0.3)		
	Total	19(20.2)	16(12.2)	-	35(9.1)	1.222(ns)	0.269
Finger millet	Harvest	43(45.7)	38(29)	8(5)	89(23.1)		
	Purchase	-	-	1(0.6)	1(0.3)		
	Total	43(45.7)	38(29)	9(5.6)	90(23.4)	9.101(*)	0.011
Teff	Harvest	44(46.8)	50(38.2)	11(6.9)	105(27.3)		
	Purchase	-	3(2.3)	1(0.6)	4(1)		
	Total	44(46.8)	53(40.5)	12(7.5)	109(28.3)	3.009(ns)	0.222

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed

Table 13 (Continued)

Variable		Agro- ecological zones				X^2-test	p-value
		Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Noug leftover	Harvest	31(33)	51(38.9)	-	82(21.3)		
	Purchase	-	2(1.5)	-	2(0.5)		
	Total	31(33)	53(40.5)	-	84(21.8)	1.198(ns)	0.274
Tomato leftover	Harvest	3(3.2)	-	-	3(0.8)		
	Purchase	18(19.1)	36(27.5)	98(61.2)	152(39.5)		
	Total	21(22.3)	36(27.5)	98(61.2)	155(40.3)	19.521(*)	0.000
Onion leftover	Harvest	1(1.1)	-	-	1(0.3)		
	Purchase	18(19.1)	36(27.5)	99(61.9)	153(39.7)		
	Total	19(20.2)	36(27.5)	99(61.9)	154(40)	7.152(*)	0.028
Cabbages leftover	Harvest	1(1.1)	-	-	1(0.3)		
	Purchase	6(6.4)	30(22.9)	59(36.9)	95(24.7)		
	Total	7(7.4)	30(22.9	59(36.9)	96(24.9)	12.848(*)	0.002
Injera & bread	households	94(100)	131(100)	160(100)	385(100)	0.0(ns)	1.00
Time of feed supplementation						31.627(*)	0.005
Morning		12(12.8)	5(3.8)	14(8.8)	31(8.1)		
Morning ,afternoon and evening		48(51.1)	71(54.2)	106(66.2)	225(58.4)		
Morning and afternoon		12(12.8)	11(8.4)	15(9.4)	38(9.9)		
Morning and evening		16(17)	41(31.3)	22(13.8)	79(20.5)		
More than three times /day		1(1.1)	2(1.5)	2(1.2)	5(1.3)		
Morning &evening in dry season ,& morning, afternoon and evening in rainy season		3(3.2)	1(0.8)	-	4(1)		
Chicks &brooding hen offer supplement s morning & evening while the rest offer morning only		1(1.1)	-	1(0.6)	2(0.5)		
Chicks offer three times /day while the rest offer two times /day		1(1.1)	-	-	1(0.3)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed

Table 14: Frequency of feed supplementation, providing feeds for birds and ways of supplementary feeding for chickens

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Frequency of feeding /day in morning					0.097(ns)	0.953
Once	93(98.9)	129(98.5)	158(98.8)	380(98.7)		
Twice	1(1.1)	2(1.5)	2(1.2)	5(1.3)		
Afternoon					10.985(*)	0.027
None	34(36.2)	47(35.9)	35(21.9)	116(30.1)		
Once	60(63.8)	83(63.4)	125(78.1)	268(69.6)		
Twice	-	1(0.8)	-	1(0.3)		
Evening					9.340(ns)	0.053
None	25(26.6)	16(12.2)	30(18.8)	71(18.4)		
Once	69(73.4)	114(87)	130(81.2)	313(81.3)		
Twice	-	1(0.8)	-	1(0.3)		
Providing feeds for birds					7.256(*)	0.027
Put feed in containers	-	1(0.8)	7(4.4)	8(2.1)		
Throw feed on the ground for collective feeding	94(100)	130(99.2)	153(95.6)	377(97.9)		
Ways of supplementary feeding					29.666(*)	0.000
Separate to different classes	-	-	12(7.5)	12(3.1)		
Together for the whole groups/group feeding/	94(100)	131(100)	140(87.5)	365(94.8)		
Chicks with their mother while all the rest (pullets, cockerel and cocks)	-	-	8(5)	8(2.1)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed.

Table 15: Basis of offering supplements, improvement perceived due to extra supplements and season of extra feeding

Variable		Agro- ecological zones				X^2-test	p-value
		Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Basis of offering supplements						45.028(*)	0.000
To increase egg yield		-	-	9(5.6)	9(2.3)		
To increase both egg & meat yield		16(17)	-	8(5)	24(6.2)		
To increase egg &meat yield ,and maintain health		78(83)	131(100)	140(87.5)	349(90.6)		
To increase egg ,meat yield, broodiness & maintain health		-	-	1(0.6)	1(0.3)		
To increase egg & meat yield, age & maintain health		-	-	1(0.6)	1(0.3)		
To increase egg ,meat yield, broodiness, age & maintain health		-	-	1(0.6)	1(0.3)		
Improvements perceived due to extra supplements						43.427(*)	0.000
Egg yield		-	-	3(1.9)	3(0.8)		
Egg yield & growth		17(18.1)	-	4(2.5)	21(5.5)		
Egg yield ,growth & improved health status		77(81.9)	131(100)	153(95.6)	361(93.8)		
Season of extra feeding for chickens						30.272(*)	0.001
Spring(April, May & June)		-	-	1(0.6)	1(0.3)		
Winter		38(40.4)	49(37.4)	101(63.1)	188(48.8)		
Summer		56(59.6)	81(61.8)	56(35)	193(50.1)		
Same feed required in all seasons		-	-	1(0.6)	1(0.3)		
Spring & winter		-	-	1(0.6)	1(0.3)		
Summer & spring		-	1(0.8)	-	1(0.3)		
Reasons for offering extra feeds & seasons at which chicken feed shortage is critical						26.138(*)	0.000
Season	Reasons						
Rainy	Lack of supplement grains & households' food leftover	56(59.6)	82(62.6)	56(35)	194(50.4)		
Dry	Lack scavengeable green feeds & worms	38(40.4)	49(37.4)	104(65)	191(49.6)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed.

4.2.2.4. Housing

The survey indicated that almost all households provided night shelter for their chickens (Table 16). The proportions of different separate chicken house types and attitude towards advantages of separate house construction differed across the agro-ecologies ($p<0.05$). However, there were no significant variations with respect to cleaning practices and frequency of cleaning of chicken house per a week among the agro-ecologies ($p>0.05$). Generally, 59.5% of the total respondents constructed separate houses for their chicken while the rest 40.5% of them housed their chickens in either part of the kitchen (7%), in the family dwelling (26.8%), perch on trees (0.5%), bamboo cages (4.7%), local bin (made from cow dung and soil mud) inside family dwelling (1.3%) and metal cages (0.3%). On the other hand, two types of separate houses (permanent and temporary chicken houses) were identified in the study area. According the households' response, permanent separate houses (56.1%) are purposely made chicken houses that are used as permanent chicken shelter all over the year while temporary separate houses (3.4%) are purposely made chicken houses that are used as temporary chicken shelter only for the dry season (i.e. until the rainy season comes) and local chicken owners housed their chickens in either part of kitchen (1.6%) or inside family dwelling (1.8%) due to the temporary houses are pulled down by heavy rains in highland agro-ecology.

Higher proportions of respondents constructed separate poultry houses in lowland (61.2%) than in midland (58.8%) and highland (57.5%). However, 13.9% of the respondents in the highland constructed temporary separate chicken houses (seasonal separate chicken houses) of which 6.4% of them housed their chickens in separate constructed house in the dry season and then housed them inside kitchen during the rainy season, and 7.4% of them housed their chickens in a separate constructed house in the dry season and then housed their chickens inside family dwelling during rainy season due to heavy rains. All respondents had not constructed seasonal separate (temporary) houses in both lowland and midland agro-ecologies. In the same way, higher proportions of households in the highland provided night shelter inside family dwelling (28.7%) than in both lowland (27.5%) and midland (24.4%). Greater proportions of households in highland provided night shelter inside local bin (made from cow dung and mud) (2.1%) than lowland (1.2%) and midland (0.8%) agro-ecologies. However, greater proportions of respondents in midland offered night shelter inside kitchen (11.5%) than highland (9.6%) and lowland (1.9%). Similarly, 0.8 % of respondents in midland gave night shelter inside metal cages but not practiced in both highland and lowland agro-ecologies. On the other hand, higher proportions of respondents in lowland delivered night shelter inside bamboo cages (6.9%) than in both midland (3.8%) and highland (2.1%). Chickens allowed Perching on trees during night time in the lowland agro-ecology (1.2%) but none of the respondents had practiced in both midland and highland agro-ecologies of the study area. This result was comparatively similar with the findings of Halima (2007) from North West of Ethiopia, Bogale (2008) from Fogera district and Wondu *et al*. (2013) from Northern Gondar of Amhara regional state in which 50.77%, 59.7% and 63% of respondents prepared a separate chicken house, respectively. However, this result was much higher than from 3.6%, 14% and 16.36% of respondents prepared a separate chicken house in Gomma wereda of Jimma Zone (Meseret, 2010), mid rift valley of Oromia (Samson & Endalew, 2010) and from North Wollo zone of Amhara regional state (Addisu *et al*., 2013), respectively.

All respondents (100%) indicated that construction of separate chicken houses is advantageous in the study area. Significant variations with respect to understanding of advantages of separate chicken houses' construction were observed among the agro-ecologies. The respondents believed that the advantages of construction of separate chicken houses were protection from predators, prevention of disease transmission and prevention of chicken damage (death) by human or large animals (45.7%), protection from predators, collection of poultry products easily and prevention from warm and coldness (34.8%), neatness (9.9%), protection from predators (8.1%), prevention of disease transmission from bird to bird /human (0.5%), disease transmission prevention and neatness (0.5%), protection from predators and neatness (0.3%) and protection from predators and suitable house equipped with air (0.3%).

There was no significant variation in line with poultry house cleaning practices and frequency of poultry houses cleaning per a week among the agro-ecological zones of the study area (Table 16). Generally, survey on cleaning practices of chicken houses revealed that 57.7% of the respondents had cleaning practices of chickens' houses while the rest 40.5% of the households cleaned their chickens' night shelter to keep a clean family house whereas 1.8% of the respondents had not totally practiced cleaning of chicken house.

The analysis of the cleaning frequency of chicken houses revealed that 66% of the total interviewed households cleaned their chickens' houses seven times per a week (once per day) followed by three times per a week (13.2%), once per a week (7.8%), twice per a week (7.5%), four times per a week (2.6%), not cleaning (2.1%), five times per a week (0.5%) and once per a month (0.3%). Similar findings have been reported from North West Ethiopia (Halima, 2007) that reported the frequency of cleaning the chicken house once a day and twice a day in a week as responded by 74.02%, and 11.06%, respectively; and in mid rift valley of Oromia (Samson & Endalew, 2012) reported that the households clean chicken house once a day and twice a day in a week as responded by 81% and 14% respectively. However, this was quite different from the ones reported by Addisu *et al.* (2013) that 37.25%, 26.42%, 25.82%, 10.13% and 0.33% of the households cleaned their chickens' houses twice a week, once a week, three times per a week, four times per a week and once a day, respectively in North Wollo zone of Amhara regional state.

A number of factors were identified that did not favor construction of separate chicken house (Appendix table 2). There was significant variation in relation to constraints in constructing separate poultry houses ($p<0.05$). The survey indicated that the major problems were lack of awareness about poultry houses (1st) and weak extension support (2nd) (17.1%) followed by lack of awareness about poultry houses (1st), capital scarcity (2nd) and weak extension support (3rd) (3.1%), labor scarcity (1st) and capital scarcity (2nd) (2.9%) ,lack of awareness about poultry houses (1st), weak extension support (2nd), capital scarcity (3rd), labor scarcity (4th) and fear of predators attack (snake) (2.6%) and land scarcity (1st), lack of awareness about poultry houses(2nd), capital scarcity (3rd) and weak extension support (4th) (2.6%) (Appendix table 2).

Similarly, significant differences were observed with respect to house construction materials, egg laying nest facilities, egg storage materials and positions of eggs on storage among the agro-ecologies of the study area (Table 17). Higher proportions of households used mud of blocks (mud and wood) as chicken house construction materials in midland (42%) than both highland (35.1%) and lowland (15%). On the other hand, only 0.8% and 1.2 % of the respondents used only wood as house construction materials in midland and lowland agro-ecology, respectively but none of the respondents used sole wood as construction material in highland agro-ecology. However, greater proportions of respondents used bamboo/ grasses with wood as chicken house construction materials in highland (14.9%) than in lowland (12.5%) and midland (4.6%) agro-ecological zone of the study area. In contrast, higher proportions of households used Iron sheet roof as house construction materials in lowland (29.4%) than in midland (11.5%) and highland (8.5%). In the same way, 1.2%, 0.6%, 0.6% and 1.2% of the respondents used wood, plastic materials, grasses, Iron sheet roof and bamboo sole as chicken house construction materials, respectively in lowland agro-ecology but none of the respondents of both midland and highland agro-ecologies had used these as construction materials. Because these materials are not good enough to provide warm and to protect extreme cold for chickens and farmers perceive chickens housed in house made from these materials become susceptible to predators during night.

The result of the survey showed that 14.3% of the respondents prepared laying nest for layers of which 4.2% and 9.9% of respondents prepared laying nest common for all layers and individual laying nest, respectively while the remaining 85.7% of them had not prepared laying nest for their layers in the study area (Table 17). Higher percent of respondents prepared laying nest in lowland (19.4%, in which common for all layers (8.1%) and individual laying nest (10.6%)) than both highland (12.8%, in which common for all layers (1.1%) and individual nest(11.2%)) and midland (9.2%, in which common for all layers (1.5%) and individual laying nest (7.6%).

In the same way, significant variations were observed with regard to distributions of egg storage materials and proportions of respondents who collected laid eggs across agro-ecologies. However, preparation of incubation place was not varied among agro-ecologies and the respondents of all agro-ecologies prepared incubation place for chickens (100%). Higher percent of households collected laid eggs properly in both highland (100%) and midland (100%) than lowland (92.5%). However, 3.8% of the respondents did not collect laid eggs at all, 2.5% of them collected eggs as necessary, and 1.2 % the households allowed eggs for incubation remain in the laying nest while eggs not used for incubation were collected for consumption in the lowland agro-ecology of the study area. This implies that there is variation in the perception of chicken producers towards the importance of proper handling (storage) and collection of eggs prior to incubation in improving hatchability and fertility of eggs. The variation might be arises due to the differences in the degree of extensional support provided across the agro-ecologies.

Proper collection and storage of eggs for up to seven days before incubating improve both hatchability and fertility of eggs thereby increase profitability of poultry production. If laid eggs are not properly collected and handled prior to incubation, they become exposing to different external environment factors and the natural pores of eggs will be enlarged. This leads to excessive loss of the internal contents of eggs (Albumen and egg yolk) and the eggs finally become spoiled with deteriorating hatchability. Frequent egg collection will prevent hens from brooding eggs or trying to eat them and will also prevent the eggs from becoming damaged or dirty (www.wapoultryequipment.net.au/Information/incubationhintsand tips.htm). It is strongly recommended that proper egg collection and storage accompanied with turning the eggs at least once per day are required to keep the embryo from dying and consequently improve hatchability and fertility of eggs.

Table 16: Housing practices, chicken house types, cleaning frequency of chicken house and advantages of separate house construction

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Separate poultry house other than family dwelling					13.799(*)	0.001
Yes ,permanent	41(43.6)	77(58.8)	98(61.2)	216(56.1)		
Yes, seasonal house	13(13.9)	-	-	13(3.3)		
No	40(42.6)	54(41.2)	62(38.8)	156(40.5)		
Chicken house types					11.319(*)	0.003
Permanent Separate house in dry &wet season	41(43.6)	77(58.8)	98(61.2)	216(56.1)		
Temporary (seasonal) separate house	13(13.9)	-	-	13(3.3)		
Separate house in dry season but housed inside family dwelling in rainy season	7(7.4)	-	-	7(1.8)		
Separate house in dry season but housed inside kitchen in rainy season	6(6.4)	-	-	6(1.6)		
Kitchen in dry and wet season	9(9.6)	15(11.5)	3(1.9)	27(7)		
Family dwelling	27(28.7)	32(24.4)	44(27.5)	103(26.8)		
Perch on trees	-	-	2(1.2)	2(0.5)		
Bamboo cages	2(2.1)	5(3.8)	11(6.9)	18(4.7)		
Bin(*Ducon*) poultry house made inside family dwelling	2(2.1)	1(0.8)	2(1.2)	5(1.3)		
Metal cages (*Bermil*)	-	1(0.8)	-	1(0.3)		
Do you believe construction of separate house advantageous?					0.00(ns)	1.00
Yes	94(100)	131(100)	160(100)	385(100)		
No	-	-	-	-		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed**.**

Table 16 (Continued)

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Advantages of separate house					101.357(*)	0.00
Protection from predators	-	18(13.7)	13(8.1)	31(8.1)		
Neatness	14(14.9)	19(14.5)	5(3.1)	38(9.9)		
Prevent disease transmission from birds to human /birds	-	1(0.8)	1(0.6)	2(0.5)		
Protection from predators ,poultry product collection easily & prevention from warm & coldness	9(9.6)	12(9.2)	113(70.6)	134(34.8)		
Prevent disease transmission from birds to human /birds & neatness	-	1(0.8)	1(0.6)	2(0.5)		
Protection from predators & neatness	-	-	1(0.6)	1(0.3)		
Protection from predators & suitable house equipped with air	-	-	1(0.6)	1(0.3)		
Protection from predators, disease transmission prevention & prevention of chicken damage (death) by human or large animals	71(75.5)	80(61.1)	25(15.6)	176(45.7)		
Cleaning practice of poultry house					0.065(ns)	0.968
Yes	54(57.4)	76(58)	92(57.5)	222(57.7)		
No	-	1(0.8)	6(3.8)	7(1.8)		
Yes ,but not purposely for chicken	40(42.6)	54(41.2)	62(38.8)	156(40.5)		
Frequency of poultry house cleaning /week					10.294(*)	0.006
Once	8(8.5)	13(9.9)	9(5.6)	30(7.8)		
Twice	5(5.3)	13(9.9)	11(6.9)	29(7.5)		
Three times	15(16)	24(18.3)	12(7.5)	51(13.2)		
Four times	3(3.2)	3(2.3)	4(2.5)	10(2.6)		
Five times	-	-	2(1.2)	2(0.5)		
Seven times	62(66)	76(58)	116(72.5)	254(66)		
Once /month	-	-	1(0.6)	1(0.3)		
Not cleaning	1(1.1)	2(1.5)	5(3.1)	8(2.1)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed.

Table 17: House construction materials, egg laying nest facilities, egg storage materials and position of eggs

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Housing construction materials					34.129(*)	0.000
Mud of blocks (mud and wood)	33(35.1)	55(42)	24(15)	112(29.1)		
Iron sheet roof	8(8.5)	15(11.5)	47(29.4)	70(18.2)		
Bamboo /grasses with wood	14(14.9)	6(4.6)	20(12.5)	40(10.4)		
Wood (eg. *Securinega Virosa)*	-	1(0.8)	2(1.2)	3(0.8)		
Plastic materials (tomato container)	-	-	1(0.6)	1(0.3)		
Grasses ,Iron sheet roof and wood	-	-	1(0.6)	1(0.3)		
Bamboo only	-	-	2(1.2)	2(0.5)		
Laying nest preparation for layers					6.356(*)	0.042
Yes	12(12.8)	12(9.2)	31(19.4)	55(14.3)		
No	82(87.2)	119(90.8)	129(80.6)	330(85.7)		
The laying nest					6.344(*)	0.042
Common for all layers	1(1.1)	2(1.5)	13(8.1)	16(4.2)		
Individual	11(11.7)	10(7.6)	17(10.6)	38(9.9)		
Lay everywhere(no purposely made laying nest)	82(87.2)	119(90.8)	130(81.2)	331(86)		
Incubating place preparation for hen					0.00(ns)	1.00
Yes	94(100)	131(100)	160(100)	385(100)		
No	-	-	-	-		
laid eggs collection practice					17.368(*)	0.000
Yes	94(100)	131(100)	148(92.5)	373(96.9)		
No	-	-	6(3.8)	6(1.6)		
As necessary	-	-	4(2.5)	4(1)		
Eggs for incubation remain in the laying nest while eggs for consumption are collected	-	-	2(1.2)	2(0.5)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed

Table **17** (Continued)

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Eggs storage materials					30.161(*)	0.000
Plastic materials without bedding	-	-	2(1.2)	2(0.5)		
Cartoon with grasses bedding	-	-	1(0.6)	1(0.3)		
Dish (metal) with grain /clothes / sand & dry grasses bedding	4(4.3)	6(4.6)	13(8.1)	23(6)		
Clay pot with grain /cotton seed/ bedding	13(13.8)	10(7.6)	6(3.8)	29(7.5)		
Plastic materials with sand bedding during dry season and with grain bedding in rainy season	16(17)	41(31.3)	104(65)	161(41.8)		
Bin(*Ducon*)with grain (teff,finger millet)/ cotton seed / sand /bedding	54(57.4)	68(51.9)	22(13.8)	144(37.4)		
Bamboo /*kirchat*/ wood with grain (finger millet) bedding	2(2.1)	1(0.8)	1(0.6)	4(1)		
Dish(metal) without bedding	-	1(0.8)	-	1(0.3)		
Eggs remain in the laying nest until incubation with chopped grasses or soil bedding	-	-	6(3.8)	6(1.6)		
Sefet (*Kunna*) with grain bedding	1(1.1)	-	2(1.2)	3(0.8)		
Gourd (*Kil*) with grain bedding	2(2.1)	2(1.5)		5(1.3)		
Gourd, bin, clay pots or bamboo with grain bedding alternatively	1(1.1)	1(0.8)	1(0.6)	3(0.8)		
Dish, bin or plastic with grain bedding alternatively	1(1.1)	1(0.8)	1(0.6)	3(0.8)		
Position of eggs on storage					0.00(ns)	1.00
On side	94(100)	130(99.2)	160(100)	384(99.7)		
Small end down	-	1(0.8)	-	1(0.3)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed

4.2.2.5. Water resources and watering

The analysis of watering and water sources revealed that significant variations were observed with respect to water sources, water supply containers, frequency of cleaning water holding containers, frequency of water provision and distance of both well and tape water from homes tead among the agro- ecologies ($p<0.05$). However, no variations were observed with regard to proportions of households who provided water for their chickens and the distance of river from their homesteads (Table 18). All of the respondents (100%) provided water for their chickens in the study area (Table 18). This was fairly similar with the findings of Halima (2007) in North West Ethiopia, Tadesse *et al*. (2013) in both Ada'a and Lume districts of East Shewa and Addisu *et al*. (2013) in North Wollo zone of Amhara regional state in which 99.45%, 100% and 100% of households offered water for chickens, respectively. However, contrasting results have been reported from Bure district (Moges *et al.*, 2010) and West Amhara regions of Ethiopia (Worku *et al*., 2012) in which 86.4% and 86.2% and 14.3% and 10.2% of the respondents provided water for their chickens during the sole dry season and year round, respectively.

With reference to water sources, the survey indicated that well (31.7%), tap water (29.1%), river (27.3%), tap water and well (6.2%), river and tap water (4.2%), and river and well (1.6%) were the drinking water sources in the study area (Table 18). Higher proportions of respondents used river as main water sources in highland (46.8%) than both midland (32.8%) and lowland (11.2%) agro-ecologies. On the other hand, greater percent of households used tap water as main water sources in lowland (45%) than both highland (29.8%) and midland (9.2%) while higher proportions of respondents used well as major water sources in midland (42.7%) than lowland (31.7%) and highland (17%). Village Kebeles in the lowland are clusters of farmhouses because they are settlement areas of farmers from overpopulated areas of Tigray and other parts of Ethiopia as well as from Sudan and Eretria as a result most of the households used tap water as drinking water source for themselves and their chickens whereas they used either river or well for large animals. Likewise, Bogale (2008) reported that local chicken owners used well (43.06%), tap water (29.2%), river (20.83%) and spring (2.78%) as drinking water sources in Fogera district.

In the same way, Worku *et al*. (2012) pinpointed that households used spring (60.2%), pipe (21.4%), river (12.2%) and pond (6.2%) as chicken drinking water sources in West Amhara regional state of Ethiopia. The findings of the survey conducted by Samson & Endalew (2010) in mid rift valley of Oromia also revealed that households used tap water (66%), river water (15%), bore hall (6%) and others (13%) as chicken drinking water sources. Tadesse *et al*. (2013) also recently reported that chicken owners used tap water (55%), Borehole water (37.2%), pond water (0.55%), river water (o.55%) and canal water (6.7%) as drinking water sources in East Shewa of Ethiopia. In the same way, Nebiyu *et al*. (2013) reported that farmers used river (65%), Tape water (20.7%) and well (14.3%) as drinking water sources in Halaba district of Southern Ethiopia.

The survey also indicated that the households used different locally made waterers to provide water for their chickens and showed variability across agro-ecologies (Table 18). Waterers made from Plastic materials, stone, wood (*Hilab* or *Galibba*), metal (dish or *bredisti*), broken pieces of pot and gourd (*Kil*) were the commonly used materials for water provision of chickens in the study area (Table 18). Waterers have always been placed in an open place which is accessible for cats, dogs, wild birds and large animals which may result in disease transmission from wild birds to chickens as well as from either dogs or cats to chickens. Thus, farmers should be strongly encouraged to minimize the risk of contamination of waterers by other animals and wild birds by placing chicken waterers and feeder in the coop/ run to reduce the risk of water and food contamination.

Moreover, the survey revealed that 86% of the respondents cleaned chicken waterers while the remaining 14 % of them did not practice cleaning of water provision materials for chicken in the study area (Table 18). Farmers cleaned chicken waterers once a day, four times a week, three times a week, once a week, twice a week, six times a week, five times a week and twice a day even if the frequency of cleaning waterers varied among agro-ecologies. This indicates that farmers seem to have good practices of keeping clean watering devices of chicken but inadequate for openly placed waterers and feeders because opened waterers are much more likely to be contaminated by dirt, soils, litter or chicken droppings. The water becomes dirty and eventually builds up of sticky materials within the waterers that provide a favorable environment for development of harmful bacteria, viruses and fungi that cause serious consequences for the health of flock and egg production. It is, therefore, highly recommendable to keep chicken waterers clean through cleaning water devices every time whenever water is provided for chickens.

This result was comparable with the findings of Halima (2007) that showed 37.25%, 34.82% and 27.93% of the households used plastic made, wooden made and clay made waterers, respectively and they cleaned their respective waterer once a day (31.52%), when it gets dirty (23.77%), every provision (6.38%) and twice a day (5.37%) while 32.96% of respondents had never cleaned their chickens' waterer at all in North West Ethiopia. It was also in parallel with the results of research conducted in Fogera district which stated that farmers used either of tap water (29.2%), river (20.83%), well (43.06%) and spring (2.78%) as waterer and they cleaned their waterers either daily (70.8%), weekly (20.8%), monthly (2.8%) and more than monthly (1.4%) (Bogale, 2008). Meseret (2010) also reported that flat plastic containers (71.2%), locally made wood (10.7%), stone dish (14.7%) and any broken material (3.4%) were the locally available waterers in Gomma wereda of Jimma zone. In the same way, Mekonnen (2007) also reported that farmers used either of wooden made drinking equipment (*Genda*) (62%), plastic made (20.4%), clay made (10.7%) and stone made (7%) as waterer in the southern regional state of Ethiopia. Similar results have also been reported from West Amhara regional state of Ethiopia that indicated that farmers used either of wooden made (61.8%), plastic made (20.4%), clay made (10.7%) and stone made (7.1%) as chicken drinking waterers (Worku *et al*., 2012).

The survey also indicated that all farmers provided water for their chickens of Adlib (70.9%), once per day (7.5%) and twice per day (21.6%) in the study area (Table 19). This was somewhat comparable with the findings of Tadesse *et al*. (2013) that revealed that 96.1% of the households provided water for their chickens at free access while the remaining 0.56% and 3.9% of them offered water for chicken morning only and morning and evening, respectively in East Shewa of Ethiopia. Likewise, Samson & Endalew (2010) also reported that farmers provided water for chickens either of throughout the day (47%), once per day

(14%), twice a day (18%), three times a day (16%) and four times a day (5%) in mid rift valley of Oromia.

Moreover, among the river water beneficiaries of the study area, their homestead was located far from the river with a distance of either <1km (3.6%), 1-5km (26%), 5-8 km (2.6%), 8-10 km (0.6%) and >10 km (0.6%). Likewise, the homestead of well water beneficiaries was situated far away from the well with a distance of either of <1km (26.5%),1-5 km (9.9%), 5-8 km (1.3%), 8-10 km (2.6%) and >10 km (0.3%). In the same way, the homestead of tap water beneficiaries was located far from the tap water a distance of either <1 km (31.7%), 1-5 km (7%) and 5-8 km (0.5%).

Generally, the current study showed that chicken producers seem to have good experience of water provision for chickens in the study area. Achievement of Sustainable improved chicken productivity requires provision of adlib fresh water on clean waterers on a regular basis. Training for chicken producers on uses of water in chicken productivity and health should be given in order to enhance sustainable improved chicken productivity there by to increase economic returns and ensure food security of small-farmers. According to (Kathy, 2012) water is critically important to chickens because it plays important roles in regulating body temperature, digesting food and eliminating body wastes. Water is by far the single greatest constituents of body and represents about 70% of total body weight. It is very crucial for egg production since an egg consists of approximately 75% water and without access to a regular, clean supply of water, a hen will be physically unable to produce eggs. Water in the crop softens the feed so that digestion can occur. Without the water, dry feed forms clumps in the crop that can press on the birds' carotid artery, decreasing blood flow to the brain. This can cause paralysis and possible death.

Table 18: Practice of watering, water resources & water supply containers for provision of water to chickens

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Practice of water provision for chickens					0.000(ns)	1.00
yes	94(100)	131(100)	160(100)	385(100)		
no	-	-	-	-		
Water resources					95.685(*)	0.000
River	44(46.8)	43(32.8)	18(11.2)	105(27.3)		
Tap water	28(29.8)	12(9.2)	72(45)	112(29.1)		
Well	16(17)	56(42.7)	50(31.2)	122(31.7)		
River and tap water	4(4.3)	1(0.8)	11(6.9)	16(4.2)		
River and well	2(2.1)	4(3.1)	-	6(1.6)		
Tap water and well	-	15(11.5)	9(5.6)	24(6.2)		
Water supply container/s					60.216(*)	0.000
Metal (dish or *bredisti*)	4(4.3)	12(9.2)	22(13.8)	38(9.9)		
Stone made	20(21.3)	28(21.4)	6(3.8)	54(14)		
Broken pieces of pot	11(11.7)	7(5.3)	13(8.1)	31(8.1)		
Plastic made	38(40.4)	65(49.6)	107(66.9)	210(54.5)		
Wood (*Hilab* or *Galibba*)	18(19.1)	17(13)	6(3.8)	41(10.6)		
Broken piece of pot & plastic	2(1.2)	-	1(0.6)	3(0.8)		
Wood(*Hilab*) & stone alternatively	1(1.1)	-	1(0.6)	2(0.5)		
Wood and metal alternatively	-	-	1(0.6)	1(0.3)		
Metal and plastic alternatively	-	2(1.5)	2(1.2)	4(1)		
Gourd (*Kil*)	-	-	1(0.6)	1(0.3)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed

Table 19: Frequency of cleaning water drinking containers & water provision and distance of water resources from homestead

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Frequency of washing containers /week					32.341(*)	0.009
Once	20(21.3)	15(11.5)	18(11.2)	53(13.8)		
Twice	9(9.6)	20(15.3)	13(8.1)	42(10.9)		
Three times	17(18.1)	17(13)	33(20.6)	67(17.4)		
Four times	2(2.1)	5(3.8)	4(2.5)	11(2.9)		
Five times	-	1(0.8)	-	1(0.3)		
Six times	1(1.1)	1(0.8)	-	2(0.5)		
Seven times	34(36.2)	42(32.1)	78(48.8)	154(40)		
None	11(11.7)	29(22.1)	14(8.8)	54(14)		
Twice / day	-	1(0.8)	-	1(0.3)		
Frequency of water providing /day					2.864(ns)	0.581
Once	8(8.5)	11(8.4)	10(6.2)	29(7.5)		
Twice	25(26.6)	27(20.6)	31(19.4)	83(21.6)		
Adlib	61(64.9)	93(71)	119(74.4)	273(70.9)		
Distance of river from homestead					6.5(ns)	0.591
<1 km	7(7.4)	4(3.1)	3(1.9)	14(3.6)		
1-5 km	38(40.4)	40(30.5)	22(13.8)	100(26)		
5-8 km	3(3.2)	5(3.8)	2(1.2)	10(2.6)		
8-10 km	1(1.1)	-	-	1(0.6)		
>10 km	-	-	1(0.6)	1(0.6)		
Distance of well from homestead					20.24(*)	0.009
<1 km	15(16)	51(38.9)	36(22.5)	102(26.5)		
1-5 km	2(2.1)	23(17.6)	13(8.1)	38(9.9)		
5-8 km	-	1(0.8)	4(2.5)	5(1.3)		
8-10 km	1(1.1)	-	9(5.6)	10(2.6)		
>10 km	-	-	1(0.6)	1(0.3)		
Distance of Tap water from homestead					31.556(*)	0.000
<1 km	30(31.9)	12(9.2)	80(50)	122(31.7)		
1-5 km	3(3.2)	13(9.9)	11(6.9)	27(7)		
5-8 km	-	2(1.5)	-	2(0.5)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed

4.2.2.6. Constraints of poultry productions

The results from both Focus group discussion and respondents' interview revealed that disease and predators were the first and second main constraints that devastating chicken productivity in the study area (Table 20). Pertaining to constraints of agro-ecological zone wise, disease and predators were the first and second chicken production constraints in all lowland, midland and highland agro-ecological zones of the study area. However, weak extension support was the third poultry production constraint in lowland agro-ecology (Table 20) whereas capital scarcity was the third most important chicken production constraints in both midland and highland agro-ecological zones of Western Tigray (Table 20).

Comparable results have been reported from Rift valley of Oromia by Hunduma *et al*. (2010) which stated that disease, predators, lack of proper health care, poor feeding; poor marketing information and replacement of indigenous chickens by exotic chickens were found to be major barriers of chicken production. In the same way, Bogale (2008) also reported that diseases (48.6%) and shortage of supplementary feeds (19.4%) were the most important chicken production constraints in Fogera District. In other study, diseases and predators were the first and second major constraints that cause loss of chickens in North West Ethiopia (Halima, 2007). Addisu *et al*. (2013) had also recently reported that diseases (60.13%), feed shortage (20.59%), predators or theft (19.8%) were the most economically important constraints of chicken production in North Wollo zone of Ethiopia. A study conducted in Metekel zone of North West Ethiopia also revealed that seasonal outbreak of diseases (mainly Newcastle disease) and predators were major factors that cause loss of chickens, and lack of credit services, limited skill of management practices (improved feeding & housing) and low productivity of local chickens were outlined as major constraints of chicken production (Solomon *et al*., 2013). The result of a survey carried out in Northern Gondar of Amhara Regional state of Ethiopia also indicated that diseases (1^{st}), predators (2^{nd}), shortage of supplementary feeds (3^{rd}), poultry housing problems (4^{th}) and lack of veterinary health services (5^{th}) were the most important constraints of village chicken production under urban system (Wondu *et al*., 2013). This result was also fairly similar with the reports of Mapiye *et al*. (2008) in Zimbabwe which indicated that shortage of feed, poor health and housing management, and socio-economic constraints (lack of markets, poor marketing management, poor infrastructural and institutional support) were the main factors that hampered village chicken productivity. It also somewhat corroborated the findings of Tadelle & Ogale (2001) who reported that diseases, scarcity of extension service, predators and parasites were the most serious constraints of village chicken production in the highland agro-ecology (Derek Wonz) while diseases and scarcity of extension services were outlined as most serious constraints of village chicken production in both midland (Gende Gorba) and lowland (Awash) agro-ecological zones of the Centeral highlands of Ethiopia. Ayalew & Adane (2013) also reported comparable results in selected Chagni town in Awi- administrative zone of Amhara region in which poultry diseases, inadequate veterinary and extension services and high feed costs were the major constraints affecting village chicken production in the area. In the same way, Nkululeko (2013) also reported that outbreak of diseases, predators, theft, shortage of feed and housing problems at night were the major challenges of poultry farming in the Zhombe communal lands of Zimbabwe. Kingori *et al*. (2010) also reported that low genetic potential of genotypes; poor nutrition, diseases and improper management were the critical challenges of village poultry production in Kenya. Fairly similar results have also been reported from three agro-ecological zones (Coastal Savannah, Rainforest and Guinea savannah) of Ghana by Hagan *et al*. (2013) in which diseases (notably Newcastle disease), predators and theft were found to be the main causes of loss of birds or reduction in chicken flock size.

However, Worku *et al*. (2012) reported slightly different findings in which predators (97.6%) as primarily and diseases (2.4%) as secondary major constraints of village chicken production in West Amhara Region of Ethiopia. Contrasting results have been also reported from Mid Rift Valley of Oromia by Samson & Endalew (2010) in which predators (birds of prey, cats and dogs and wild animals) (65.3%), diseases (34%) and accident (0.7%) were the largest threat to village chicken production in the area. Thus, training for farmers should be given on how to address these constraints through proper management that could help to improve productivity of local chickens.

Table 20: Poultry production constraints in three agro-ecological zones of Western zone of Tigray

Lowland agro-ecology													
Factors	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	Index
Disease	123	37	1	0	0	0	0	0	0	0	0	0	0.151
Predators	28	95	27	6	4	0	0	0	0	0	0	0	0.140
Capital scarcity	5	22	19	5	12	26	18	31	19	3	0	0	0.093
Lack of credit services	0	0	0	18	20	37	41	30	12	2	0	0	0.082
Labor scarcity	0	0	0	0	0	4	2	1	24	37	92	0	0.035
Lack of market place	0	0	0	24	20	28	47	29	12	0	0	0	0.084
Weak extension support	0	0	37	52	53	18	0	0	0	0	0	0	0.111
Lack of veterinary services	0	0	62	50	43	5	0	0	0	0	0	0	0.116
Land scarcity	4	6	15	5	8	21	43	57	1	0	0	0	0.085
Lack of road access for poultry product trans.	0	0	0	0	0	14	5	5	68	68	0	0	0.050
Lack of market –oriented improved breed (s)	0	0	0	0	0	7	4	7	24	50	68	0	0.039
Theft or poor housing system	0	0	0	0	0	0	0	0	0	0	0	160	0.013
Midland agro-ecology													
Disease	91	34	6	0	0	0	0	0	0	0	0	0	0.149
Predators	26	83	22	0	0	0	0	0	0	0	0	0	0.141
Capital scarcity	10	12	35	55	4	15	0	0	0	0	0	0	0.121
Lack of credit services	0	0	0	0	17	20	31	30	31	2	0	0	0.073
Labor scarcity	0	0	0	0	1	0	0	6	9	66	49	0	0.036
Lack of market place	0	0	0	0	13	20	20	28	30	19	1	0	0.067
Weak extension support	0	0	28	22	35	30	15	0	0	1	0	0	0.104
Lack of veterinary services	0	0	40	48	42	1	0	0	0	0	0	0	0.115
Land scarcity	4	2	0	6	5	24	33	33	24	0	0	0	0.077
Lack of road access for poultry product trans.	0	0	0	0	14	21	32	32	28	4	0	0	0.072
Lack of market –oriented improved breed (s)	0	0	0	0	0	0	0	2	9	39	81	0	0.032
Theft or poor housing system	0	0	0	0	0	0	0	0	0	0	0	131	0.013

*R1, R2, and R3…R12=Rank 1, 2, 3…12, respectively; and Index=Sum of (12 for Rank1+11 for Rank2+…+1for Rank12) given for an individual factor divided by the sum of (12 for Rank 1+ 11 for Rank 2+…+ 1 for Rank 12) for overall factors.

Table 20 (continued)

Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	Index
Highland agro-ecology													
Disease	66	20	8	0	0	0	0	0	0	0	0	0	0.149
Predators	18	66	10	0	0	0	0	0	0	0	0	0	0.142
Capital scarcity	8	7	20	38	3	14	3	0	0	1	0	0	0.117
Lack of credit services	0	0	0	0	16	14	21	21	21	1	0	0	0.074
Labor scarcity	0	0	0	0	0	0	0	10	2	50	32	0	0.037
Lack of market place	0	0	0	1	10	18	13	18	23	11	0	0	0.069
Weak extension support	0	0	18	19	18	27	11	1	0	0	0	0	0.103
Lack of veterinary services	0	0	38	27	29	0	0	0	0	0	0	0	0.117
Land scarcity	2	1	0	9	11	5	28	16	22	0	0	0	0.078
Lack road access for poultry product trans.	0	0	0	0	7	16	18	26	25	2	0	0	0.070
Lack of market –oriented improved breed (s)	0	0	0	0	0	0	0	2	1	29	62	0	0.031
Theft or poor housing system	0	0	0	0	0	0	0	0	0	0	0	94	0.013
Western Zone of Tigray													
Disease	280	91	14	0	0	0	0	0	0	0	0	0	0.1561
Predators	72	244	59	6	4	0	0	0	0	0	0	0	0.1465
Capital scarcity	23	41	74	98	19	55	21	31	19	4	0	0	0.1129
Lack of credit services	0	0	0	6	53	34	93	81	64	5	0	0	0.0676
Labor scarcity	0	0	0	0	1	4	2	17	35	153	173	0	0.0374
Lack of market place	0	0	0	7	43	38	80	75	65	30	1	0	0.0652
Weak extension support	0	0	83	93	106	75	26	1	0	1	0	0	0.1111
Lack of veterinary services	0	0	140	81	114	1	0	0	0	0	0	0	0.1057
Land scarcity	10	9	15	20	24	50	104	106	47	0	0	0	0.0844
Lack of road access for poultry product trans.	0	0	0	6	21	37	55	63	121	74	0	0	0.0635
Lack of market –oriented improved breed (s)	0	0	0	0	0	7	4	11	34	118	211	0	0.0361
Theft or poor housing system	0	0	0	0	0	0	0	0	0	0	0	385	0.0134

*R1, R2, and R3…R12=Rank 1, 2, 3…12, respectively; and Index=Sum of (12 for Rank1+11 for Rank2+…+1for Rank12) given for an individual factor divided by the sum of (12 for Rank 1+ 11 for Rank 2+…+ 1 for Rank 12) for overall factors.

4.2.2.6.1. Disease and predators

The survey indicated that there was insignificant variation with regard to the proportions of households with serious disease outbreak experiences among the agro-ecologies (Appendix table 3). Generally, 99% of the total households interviewed had experience of serious disease outbreak and they recognized sick birds through observing symptoms of the prevailing poultry disease while the remaining 1% of them had not experience of serious disease outbreak. On the contrary, proportions of respondents who practiced different techniques of treating sick birds differed across agro-ecologies. Highest proportions of households treated their sick birds by themselves either by purchasing drugs from private clinics or traditional treatments in lowland (84.4%) as compared with both midland (66.4%) and highland (68.1%) agro-ecological zones of the study area. However, greatest proportions of respondents called in either veterinarians or development agents for treating the sick birds in midland (23.7%) in comparison with both highlands (22.3%) and lowland (14.4%) agro-ecologies. Overall, 74.3% of the respondents treated their sick chickens by themselves followed by called in either veterinarians or development agents (19.5%), cull/kill them immediately (0.3%) and slaughter them immediately for home consumption (0.5%) while 4.4% of them did nothing for treating chickens when their chickens become sick. This result was somewhat comparable with the findings of Meseret (2010) in Gomma Wereda of Jimma zone in which (36.7%) of the farmers treated sick birds by themselves followed by sell them all immediately (30.6%), slaughter them for home consumption and sell them all immediately (20.6%) and slaughter them for home consumption (12.2%).

No significant variations were observed with respect to the proportions of households who practiced either of the two techniques of managing dead birds (throwing and burying) across the agro-ecologies. In general, 91.2% of the respondents threw away dead chickens in and around their backyards which are accessible to pet animals (cat, dogs), wild cats (*Mutsu*), wild birds and other live chickens while they are scavenging / searching feeds. As a result, there may be a contamination of both waterers and feeders by either of pet animals or wild predators which may serve as a means of disease/ infection/ transmission among wild and domestic chickens, wild/domestic predators and domestic chickens.

Only 8.8% of the total respondents had practiced burying of dead chickens with the perception of minimizing disease transmission among domestic chickens and pet animals to domestic chickens and keeping the sanitation of both family dwelling and backyards properly. This result was in agreement with that of Meseret (2010) who reported that 91.1% of the respondents threw away dead chickens in Gomma wereda of Jimma zone. Similarly, Nebiyu *et al*. (2013) reported that farmers offered dead chickens to pet animals (83.6%) and burying (16.4%) as a means of dead birds disposal in Halaba district of Southern Ethiopia

Awareness creation with respect to how to avoid means of disease transmissions and disease prevention techniques should be given in a strengthened manner. This will have a paramount significance not only for increasing chicken productivity performance but also for conserving diverse germ plasm useful for genetic improvement through appropriate genetic improvement methods.

The survey also indicated that controls of free movements of chickens were practiced all times in the study area. There were significant differences with reference to proportions of farmers who practiced either control or no control of free movement of chickens with diverse reasons among the agro-ecological zones. Highest proportions of chicken owners practiced control free movement of chickens in lowland (71.2%) in relation to both highland (62.8%) and midland (48.1%) agro-ecologies. Overall, 61.3% of the total respondents practiced control of free movement of chickens all times with the basis of either protection from predators' attack (48.8%), protection from predators attack and birds from picking and destroying crops and vegetables (7.5%), protection birds from picking and destroying crops and vegetables (1.3%), protection from predators attack and avoid risk of contagious disease (1.3%), protection from predators attack, avoid risk of contagious disease and protection from mixing with village flock (1.3%), avoiding risk of contagious disease (0.5%), avoiding risk of contagious disease and protection birds from mixing with village flock (0.3%) and protection from predators attack and mixing with village flock (0.3%).

The survey also revealed that there were practices of controlling free movement of chickens during the times of disease outbreaks. Proportions of respondents who practiced control of free movement of chickens at time of disease outbreak were significantly different among the agro-ecologies. Maximum proportions of households had practiced control of free movement of chickens during disease outbreak in lowland (24.4 %) as compared to midland (4.6%) and highland (4.3%). Generally, 12.7% of the respondents practiced control of free movement of chickens at time of disease outbreak in the study area. However, this result was slightly higher than from the results of Meseret (2010) who reported that 8.3% of the households practiced free movement of chickens during disease outbreak in Gomma wereda of Jimma zone.

On the contrary, the proportions of respondents who replied that chickens scavenge mixed and unmixed with neighbors and various sources of chicken infection did not differ among the agro-ecological zones. Generally, 92.2% of the respondents replied that their chickens scavenged mixed with neighbors while 8.8% of them reported that chickens scavenged without mixing with neighbors. Likewise, the households responded that the sources of chickens' infections were either of chickens from market (26.2%), chickens from neighbors (2.9%) , both chicken from market and neighbors (2.3%), contaminated feeds (dead chicken body and same waterers used pet animals, wild birds and domestic chicken) (1%), fluctuations of temperature and cold (0.5%), both chickens from market and contaminated feeds (1%) and dirty poultry house and non-chemical spraying properly (0.5%) while the remaining 64.7% of the respondents replied that chickens 'infections arose unknowingly. Similarly, Bogale (2008) also reported that incoming flock (chicken from market) (51.4%), own flock (37.5%) and flocks from neighbors (20.8%) were found to be major sources of chicken infections in Fogera district.

Overall, access to veterinary health services seemed to be very adequate (88.8%) but limited to providing diagnosis and drug provision services of chickens in the study area (Appendix Table 4). Out of the respondents who had access to veterinary services, 77.4% of them received advisory services. Almost all respondents replied that they always ask to any veterinarian to give those drugs and diagnosis services for chickens but they do not still get a feed back of both services in the prevailing animal health clinics of the study area. Respondents considered these veterinary services of the study area as center of advisory services for chickens. Moreover, local chickens' owners confirmed that they are highly interested for expansion of chicken production if their questions (drugs and diagnosis services) are answered with concerning bodies because they considered chickens as poor man's bank (serve as immediate sources of income for immediate actions (duties). Almost all respondents (99.7%) had not practiced vaccination of their chickens in the study area while the remaining o.3 % of them had recently practiced chicken vaccination. Similarly, Bogale (2008) reported that 9.7%, 19.4% and 22.2% of the respondents had accessed of getting diagnosis, advisory and provision of drug services in Fogera district.

The result of the survey also indicated that the governmental veterinary health services are located far away from the homesteads of the respondents with a distance of less than one kilometer (6%), l-5 km (29.1%), 5-8 km (17.9%), 8-10 km (11.7%) or greater than ten kilometers (22.9%). In the same way, the private veterinary health clinics provided limited services for the farmers in the study area and they are situated far away from the residential areas of the respondent's with a distance of either less than one kilometer (0.8%), 1-5 km (1.6%), 5-8 km (0.8%) or 8-10 km (0.3%).

The survey also revealed that both diseases and predators are highly prevalent in the study area (Table 20). The results of both respondents' interview ranking indices and Focus discussion groups revealed that Newcastle disease (1^{st}), fowl salmonella (2^{nd}), coccidiosis (3^{rd}), fowl typhoid (4^{th}), fowl cholera (5^{th}), fowl pox (6^{th}) and fowl coryza (7^{th}) were the major and economically important diseases that hinder the expansion of village chicken production in the study area (Table 21). Specifically, Fowl salmonella (1^{st}), Newcastle disease (2^{nd}), coccidiosis (3^{rd}), fowl typhoid (4^{th}), fowl cholera (5^{th}), fowl pox (6^{th}) and fowl coryza (7^{th}) were the main prevalent diseases in lowland agro-ecology (Table 21). On the contrary, Newcastle disease (1^{st}), fowl salmonella (2^{nd}), coccidiosis (3^{rd}), fowl typhoid (4^{th}), fowl cholera (5^{th}), fowl pox (6^{th}) and fowl coryza (7^{th}) were the most economically important poultry diseases in the midland agro-ecology (Table 21) while newcastle disease (1^{st}),coccidiosis (2^{nd}), fowl salmonella (3^{rd}), fowl typhoid (4^{th}), fowl cholera (5^{th}), fowl pox (6^{th}) and fowl coryza (7^{th}) were the main prevalent poultry diseases in the high agro-ecology (Table 21). Likewise, Meseret (2010) reported that Newcastle disease (34.42%), infectious bronchitis (27.92%), infectious bronchitis and external parasites (25.97%) and coccidiosis (11.69%) were the most economically important poultry diseases in Gomma wereda of Jimma zone. Similarly, Newcastle disease was reported as most economically important poultry disease in Fogera district (Bogale, 2008) and rift valley of Oromia (Hunduma *et al*., 2010). Besides, Hailu (2012) reviewed that Newcastle diseases, infectious bursal disease and Marek's diseases become serious threats to poultry production in Ethiopia.

Prevalence of predators was the 2nd pronounced constraint of chicken production in the study area. Results of both individual interview and focus group discussion showed that birds of prey (Black kite, Milvus migrans locally known "Shilla" and Augur buzzard, Bueteo rufofuscus, locally known as "Chilfit"), the Abyssinian Genet, Genetta Abyssinica locally known as "Silhlohot"), Abyssinian cat locally called "Mutsu"), domestic cats, dogs,Snakes and rats (locally called"AnchiwaEimer") were the most common important predators that cause chicken losses in the study area even if their prevalence rates varied across the agro-ecologies. This agreed with the findings of Hunduma *et al*., 2010) revealed that birds of prey locally called "Culullee" (34%), cats & dogs(16.3%) and wild animals (15%) were identified as major causes of village chicken mortality in Oromia Rift Valley. Mekonnen (2007) also reported that snakes, rats, dogs, cats and foxes were main predators that caused losses especially in young birds in Dale, Wonsho and Loka Abaya weredas of SNNPRs. Likewise, Aberra (2000) reported that wild birds (eagle, hawk, etc) and wild cat (locally called "Shelemetmat") were the most common chicken predators during the dry and rainy seasons, respectively in the southern part of Ethiopia.

Predator is the second causes of chicken losses in the study area because free scavenging production system is a predominant one and serves as a conducive environmental condition for the existence of highly prevalence of predators. Chicken losses to predators can be greatly reduced by the adoption of confinement production system (i.e. feeding & watering chickens with in a confined area). Proper housing protects the flocks from unfavorable weather conditions and reduces losses due to predation. Adoption of hay box brooder is the best option to reduce heavy losses of young chicks through predation. It is highly recommended that farmers should practice confinement of chickens in order to reduce chicken losses due to both nocturnal and diurnal predators.

Table 21: Ranking of common poultry diseases in three agro-ecological zones of Western Tigray

Name of disease	Symptoms	R1	R2	R3	R4	R5	R6	R7	Index
				Lowland agro-ecology					
Fowl salmonella	Yellowish green droppings(diaharia)	97	14	8	20	18	0	2	0.218
Newcastle disease	Upward neck erection, diaharia, unable to move, dullness	40	82	17	13	5	2	0	0.215
coccidiosis	Reddish diaharia, loss of appetite	0	33	74	25	11	15	1	0.170
Fowl typhoid	Loss of appetite ,thirsty ,yellowish diaharia, respiratory difficulty	19	8	17	58	48	9	0	0.153
Fowl cholera	Greenish diaharia, whitish discharge from eye, swelling of wattle	2	10	32	34	68	11	2	0.107
Fowl coryza	Face swelling ,discharge from mouth and noise	1	0	0	0	6	100	52	0.063
Fowl pox	Swelling of eye, become blind, highly communicable	0	12	11	9	3	22	102	0.074
				Midland agro-ecology					
Fowl salmonella	>>	56	3	32	10	22	4	0	0.192
Newcastle disease	>>	57	56	5	3	4	2	0	0.222
coccidiosis	>>	0	34	51	20	5	14	3	0.165
Fowl typhoid	>>	3	21	7	39	30	27	0	0.136
Fowl cholera	>>	4	3	26	25	60	9	0	0.133
Fowl coryza	>>	0	0	0	0	5	53	69	0.053
Fowl pox	>>	7	10	6	30	1	18	55	0.099

*R1, R2, and R3…R7=Rank 1, 2, 3…7, respectively; and Index=Sum of (7 for Rank1+6 for Rank2+…+1for Rank7) given for an individual factor divided by the sum of (7 for Rank 1+ 6 for Rank 2+…+ 1 for Rank 7) for overall factors.

Table 21 (continued)

Name of disease	Symptoms	R1	R2	R3	R4	R5	R6	R7	Index
Highland agro-ecology									
Fowl salmonella	Yellowish green droppings(diaharia)	19	2	29	11	27	3	1	0.164
Newcastle disease	Upward neck erection, diaharia, unable to move, dullness	61	26	2	0	1	2	0	0.233
coccidiosis	Reddish diaharia, loss of appetite	0	38	15	25	2	10	2	0.167
Fowl typhoid	Loss of appetite ,thirsty ,yellowish diaharia, respiratory difficulty	5	23	8	16	7	33	0	0.141
Fowl cholera	Greenish diaharia, whitish discharge from eye, swelling of wattle	3	1	28	9	48	1	2	0.136
Fowl coryza	Face swelling ,discharge from mouth and noise	0	1	1	1	3	32	54	0.055
Fowl pox	Swelling of eye, become blind, highly communicable	4	1	9	30	4	11	33	0.103
Western Zone of Tigray									
Fowl salmonella	>>	172	19	69	41	67	7	3	0.193
Newcastle disease	>>	158	164	24	16	10	6	0	0.219
coccidiosis	>>	0	105	140	70	18	39	6	0.165
Fowl typhoid	>>	27	52	32	113	85	69	0	0.142
Fowl cholera	>>	9	14	86	68	176	21	4	0.134
Fowl coryza	>>	1	1	1	1	14	185	175	0.058
Fowl pox	>>	11	23	26	69	8	51	190	0.089

*R1, R2, and R3…R7=Rank 1, 2, 3…7, respectively; and Index=Sum of (7 for Rank1+6 for Rank2+…+1for Rank7) given for an individual factor divided by the sum of (7 for Rank 1+ 6 for Rank 2+…+ 1 for Rank 7) for overall factors.

4.2.2.7. Marketing system of chickens and eggs

Indigenous chickens are mainly kept for egg and meat production in the study area. Local chicken owners usually use the produced eggs either for breeding (hatching), selling and home consumption. Overall, the result revealed that 99.7% of the respondents had participated in selling of chicken products while the rest 0.3% of them did not practice selling (Table 22). Depending upon the location of farm dwelling, farmers usually sell most of their chicken products in either of the same village (64.2%), woreda market (3.3%) and both same village and woreda market (32.2%).

There were significant variations with respect to the proportions of respondents who practiced selling of chicken products in different market sites among the agro-ecologies of the study area ($p<0.05$). Higher proportions of households sold chicken products to their neighbors in the same village (98.8%) than in midland (67.9%). None of the respondents had practiced selling of chicken products in the same village of the highland agro-ecology. However, greatest proportions of respondents sold their chicken products in either of wereda market (9.6%) or both same village and wereda market (90.4%) as compared to both midland (3.1% and 28.2%) and lowland (3.3% and 1.2%, respectively). Similarly, Bogale (2008) also reported that 41.7% and 33.3% of the respondents sold their chicken products in the nearest market and woreda market during market days, respectively while 19.4% sold their products within their respective kebeles during non-market days. In her study in Gomma wereda of Jimma zone, Meseret (2010) also reported that chicken products were sold either at the farm gate, primary market (small village market) or at secondary market (at large wereda town). She also pinpointed that informal marketing of chicken products in an open market was a common practice in Gomma wereda.

The result of the study also indicated that there were significant variations with reference to the location of market sites in either of the same village or wereda market from the homesteads of the respondents across the agro-ecological zones of the study area. Overall, 96.4% of the respondents sold their chicken products in the market site of same villages through traveling a distance of either less than one kilometer (5.2%), 1-5km (34.5%), 5-8km

(23.1%), 8-10 km (22.6%) or greater than ten kilometers (10.9%) whereas the remaining 3.3% and 0.3% of them did not sell there and sell at all, respectively . In the same way, 35.6% of the respondents sold their chicken products in th market site of wereda town(capital) by traveling a distance of either less than one kilometer (0.3%),1-5 km (2.9%), 5-8 k m (2.6%), 8-10 km (4.9%) and greater than ten kilometers (24.9%) while the remaining 64.1% and 0.3% of them did not sell chicken products in the wereda market and did not sell their products at all. It was also observed that marketing of chicken products (live chickens and eggs) have been carried out throughout the week with one regular market day at the center of each kebele in lowland and rarely practiced in midland agro-ecology. However, exchanges of chicken products have been taken place with one regular market day per a week in the high agro-ecology of the study area. Furthermore, farmers are highly interested to sell their chicken products in the wereda market rather than selling in the market of the same village because chicken products are sold with relatively higher prices in the wereda market than in the market site of the same village.

Pertaining to regular client (buyer) of chicken products, the result also showed that there were significant variations with regard to the proportions of regular clients and types of market flow of chicken practiced among the agro-ecological zones of the study area (Table 23). Generally, 78.4% of the respondents sold their chicken products directly to consumers (65.2%) followed by both collectors in market and sell to consumers (19.5%) and both village collectors and sell to consumers (1.8%) following both directly and indirectly market flow channel (34.5%) in the study area. This result was somewhat comparable with the reports of Meseret (2010) that live chickens and eggs have passed through several individuals before reaching to consumers in Gomma wereda of Jimma zone and she also outlined that market collectors and consumers were the major clients of chicken products in Gomma wereda. However, contrasting results have been reported from North Wollo zone that 92.16% and 7.84% of the respondents sold live chickens indirectly and directly to consumers, respectively (Addisu *et al*., 2013).

The result of the survey indicated that the distribution of marketing problem types did not differ among the agro-ecological zones of the study area (Table 22). The respondents replied that poor infrastructure and lack of information (28.8%), poor infrastructure (22.4%), lack of market place and infrastructure (15.6%), lack of information (12.5%), lack of market place (10.4%), poor sales(demand seasonality) (2.3%), domination of market by other traders (0.8%), unstable chicken prices (0.3%) and poor sales and lack of information (0.3%) were the main marketing problems while the remaining 6.2 % of the respondents did not face any chicken marketing problems at all in the study area. In a study conducted in North Wollo zone of Amhara Regional State revealed that instable chicken price (40.85%), demand seasonality (29.41%) and lack of market place (29.74%) were found to be the most important constraints of marketing chicken products (Addisu *et al*., 2013). Similarly, Meseret (2010) also reported that demand seasonality (42.3% and 41.7%), unstable prices (19.4% and 24.4%) and unstable price and demand seasonality (38.3% and 33.9%) were the problems of live chickens and eggs marketing, respectively, in Gomma wereda of Jimma zone.

The result of the survey indicated that all respondents (100%) replied that the price of live chickens vary based on different determinant factors. According to the result of both respondents 'interview ranking indices and ranking by focus group discussion confirmed that plumage color (1^{st}), body weight (2^{nd}), comb type (3^{rd}), shank color (4^{th}), smoothness of legs(shank) (5^{th}), sex (6^{th}), spur presence (7^{th}), length of legs (8^{th}), head shape (9^{th}) and market site (10^{th}) were the major factors that cause variation in the price of live chickens in the study area (Table 23). The pooled result of the survey and focus group discussions indicated that price determinant factors were ranked similarly in both lowland and midland agro-ecologies like plumage color (1^{st}), body weight (2^{nd}), comb type (3^{rd}), shank color (4^{th}), smoothness of legs (shank) (5^{th}), sex (6^{th}), spur presence (7^{th}), length of legs (8^{th}), head shape (9^{th}) and market site (10^{th}) (Table 23). However, ranking of factors in highland agro-ecology was slightly different from both agro-ecologies in which rank positions of both body weight and comb type were reversed (Table 23).

Similarly, Bogale (2008) reported that plumage color, comb type, plumage color and comb type, body weight, age, sex and seasons were relevant factors that brought variations on the price of live chickens at market level in Fogera district. Besides, Addisu *et al*. (2013) also reported that the prices of live chickens were determined based on body weight (41.83%), combination of comb type and plumage color (32.35%) and plumage color (25.82%) in buying and selling marketing system in North Wollo zone of Ethiopia. In the same way, Halima (2007) also reported that seasonal demand (holidays and fasting seasons), lack of infrastructure, plumage color, size, age, sex, market sites and health status of the chickens had great effect on live chicken prices in North West Ethiopia. The price of poultry and poultry products were strongly affected by season in the Centeral highlands of Ethiopia (Tadelle & Ogale, 2000). This result somewhat corroborated the findings of Hunduma *et al*. (2010) in which demand and supply of chicken products which notably related to religious festivals (mainly Christian festivals), market day types (holiday versus ordinary market days) together with plumage color (45.4%), physical stand and shank length (37.1%), comb type (8.6%) and parents' performance (pedigree) (1.1%) were the major price determinant factors of chickens and chicken products in Rift Valley of Oromia. Melkamu & Wube (2013) also reported that annual festivity time and coat/plumage color were the two pronounced factors in determination of chicken products' prices in Debsan Tikara kebele at Gondar Zuria woreda, North Gondar, Ethiopia. In Uganda, breed type (local chicken highly preferred to exotic breeds because of their tasty (56.7%) products) and annual social and religious festivity were the critical price determinant factors of chicken products in Kampala city (Emuron *et al*., 2010). In a similar context, Mengesha *et al*. (2008) also reported that body weight (34.2%), plumage color (33.3%) and comb type (32.4%) were the most predominant criterias commonly used for judging the prices of local chickens, and purchasing power of consumers' (33.4%), fasting (33.2%) and availability of products (32.5%) were the major remarkable causes of the price fluctuations of village chicken and chicken products in Jamma district of South Wollo zone of Ethiopia. Samson & Endalew (2010) also reported that seasonal supply and demand (especially Orthodox Christian holiday vs fasting seasons) and market day types (Ordinary days vs Market days) and plumage colors (brown, gray and red (72%), black (18%) and white (10%) in their order of preference) were the predominant factors that caused price variability of chicken and chicken products in Mid Rift Valley of Oromia. In Jordan, the chickens' phenotype, sex and age, and by season of the year were the major prices determining factors of chickens in the area (Abdelqader *et al*., 2007).

Table 22: Market outlets, distance of market place from homestead and marketing constraints of chicken products in Western zone of Tigray

Variable	Agro- ecological zones				X2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Market outlets					245.42(*)	0.00
In the same village	-	89(67.9)	158(98.8)	247(64.2)		
In woreda market	9(9.6)	4(3.1)	-	13(3.3)		
In the same village & woreda market	85(90.4)	37(28.2)	2(1.2)	124(32.2)		
Not selling at all	-	1(0.8)	-	1(0.3)		
Distance of the market place in the same village from homestead					52.945(*)	0.00
<1km	1(1.1)	4(3.1)	15(9.4)	20(5.2)		
1-5km	32(34)	18(13.7)	83(51.9)	133(34.5)		
5-8km	29(30.9)	33(25.2)	27(16.9)	89(23.1)		
8-10km	17(18.1)	49(37.4)	21(13.1)	87(22.6)		
>10km	6(6.4)	22(16.8)	14(8.8)	42(10.9)		
Not selling there	9(9.6)	4(3.1)	-	13(3.3).		
Not selling at all	-	1(0.8)	-	1(0.3)		
Distance of the market place in the woreda from homestead					9.623(*)	0.008
<1km	1(1.1)	-	-	1(0.3)		
1-5km	11(11.7)	-	-	11(2.9)		
5-8km	10(10.6)	-	-	10(2.6)		
8-10km	13(13.8)	6(4.6)	-	19(4.9)		
>10km	59(62.8)	35(26.7)	2(1.2)	96(24.9)		

* (p<0.05) & ns (p>0.05) and n=number of respondents interviewed per agro-ecology

Table 22 (Continued)

Variable	Agro- ecological zones				X2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Not selling there	-	89(67.9)	158(98.8)	247(64.1)		
Not selling at all	-	1(0.8)	-	1(0.3)		
Your regular client of chicken product					74.922(*)	0.00
Sell to consumers	57(60.6)	85(64.9)	160(100)	302(78.4)		
Collectors in market & sell to consumers	37(39.4)	38(29)	-	75(19.5)		
Village collectors & sell to consumers	-	7(5.3)	-	7(1.8)		
Not selling at all	-	1(0.8)	-	1(0.3)		
Chicken marketing problems					3.683(ns)	0.159
Unstable chicken prices	-	-	1(0.6)	1(0.3)		
Poor sales (demand seasonality),lower price in fasting time & higher price in non-fasting time)	-	-	9(5.6)	9(2.3)		
Lack of market place	-	-	40(25)	40(10.4)		
Poor infrastructure (road & market)	30(31.9)	57(43.5)	1(0.6)	88(22.9)		
lack of information	-	26(19.8)	22(13.8)	48(12.5)		
Poor infrastructure & lack of information	53(56.4)	23(17.6)	35(21.9)	111(28.8)		
Lack of market place & information	11(11.7)	24(18.3)	25(15.6)	60(15.6)		
Market dominated by other traders	-	-	3(1.9)	3(0.8)		
Poor sales & lack of market place	-		1(0.6)	1(0.3)		
No problem	-	1(0.8)	23(14.4)	24(6.2)		
Market flow of live chicken & eggs					198.987(*)	0.00
Directly to consumers	12(12.8)	79(60.3)	160(100)	251(65.2)		
Both directly & indirectly to consumers	82(87.2)	51(38.9)	-	133(34.5)		
Not selling at all	-	1	-	1(0.3)		
Price variation in live chicken					000(ns)	1.00
yes	94(100)	131(100)	160(100)	385(100)		
no	-	-	-	-		

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Table 23: Ranking of price determinants of live chickens in three agro-ecological zones of Western Tigray

Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Lowland agro-ecology											
Plumage color	131	28	0	0	1	0	0	0	0	0	0.1787
Body weight	29	57	28	45	0	1	0	0	0	0	0.1535
Comb type	0	73	84	1	0	0	0	2	0	0	0.1529
Shank color	0	0	47	105	2	0	0	0	0	6	0.1286
Smoothness of legs (shank)	0	0	1	0	104	46	2	7	0	0	0.1015
sex	0	1	0	3	50	76	1	29	0	0	0.0913
Spur presence	0	0	0	6	2	29	122	1	0	0	0.0786
Length of legs	0	1	0	0	1	8	29	121	0	0	0.0608
Head shape	0	0	0	0	0	0	0	0	160	0	0.0365
Market site	0	0	0	0	0	0	6	0	0	154	0.0175
Midland agro-ecology											
Plumage color	127	4	0	0	0	0	0	0	0	0	0.1806
Body weight	14	51	50	16	0	0	0	0	0	0	0.1558
Comb type	0	65	62	0	0	0	0	4	0	0	0.1511
Shank color	0	0	19	110	1	0	0	0	0	1	0.1285
Smoothness of legs (shank)	0	0	0	0	110	16	5	0	0	0	0.1051
sex	0	0	0	4	16	60	1	50	0	0	0.0799
Spur presence	0	0	0	1	4	50	75	1	0	0	0.0808
Length of legs	0	1	0	0	0	5	50	75	0	0	0.0635
Head shape	0	0	0	0	0	0	0	0	131	0	0.0362
Market site	0	0	0	0	0	0	1	0	0	130	0.0185

*R1, R2, and R3…R10=Rank 1, 2, 3…10, respectively; and Index=Sum of (10 for Rank1+9 for Rank2+…+1for Rank10) given for an individual factor divided by the sum of (10 for Rank 1+ 9 for Rank 2+…+ 1 for Rank 10) for overall factors.

Table 23 (continued)

Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Highland agro-ecology											
Plumage color	86	8	0	0	0	0	0	0	0	0	0.1802
Body weight	8	28	48	10	0	0	0	0	0	0	0.1520
Comb type	0	55	39	0	0	0	0	0	0	0	0.1561
Shank color	0	0	7	75	11	0	0	0	0	1	0.1253
Smoothness of legs (shank)	0	0	0	0	75	18	1	0	0	0	0.1052
sex	0	0	0	8	8	27	3	48	0	0	0.0764
Spur presence	0	0	0	1	0	48	42	3	0	0	0.0820
Length of legs	0	3	0	0	0	1	48	42	0	0	0.0677
Head shape	0	0	0	0	0	0	0	0	94	0	0.0364
Market site	0	0	0	0	0	0	1	0	0	93	0.0188
Western Zone of Tigray											
Plumage color	344	40	0	0	1	0	0	0	0	0	0.1796
Body weight	51	136	126	71	0	1	0	0	0	0	0.1531
Comb type	0	193	185	1	0	0	0	6	0	0	0.1530
Shank color	0	0	73	290	14	0	0	0	0	8	0.1277
Smoothness of legs (shank)	0	0	1	0	289	80	8	7	0	0	0.1036
sex	0	1	0	15	74	163	5	127	0	0	0.0837
Spur presence	0	0	0	8	6	127	239	5	0	0	0.0801
Length of legs	0	5	0	0	1	14	127	238	0	0	0.0634
Head shape	0	0	0	0	0	0	0	0	385	0	0.0363
Market site	0	0	0	0	0	0	8	0	0	377	0.0193

*R1, R2, and R3…R10=Rank 1, 2, 3…10, respectively; and Index=Sum of (10 for Rank1+9 for Rank2+…+1for Rank10) given for an individual factor divided by the sum of (10 for Rank 1+ 9 for Rank 2+…+ 1 for Rank 10) for overall factors.

4.2.2.8. Extension services

The survey revealed that 99% of the respondents confirmed that they have discussed about poultry production and related problems with the development agents in either of agent office (62.3%), agent office and farm house (22.9%), agent office, farm house and church (6.8%), agent office and church (5.5%) or church (1.6%) in the study area (Table 24). No differences were observed with respect to the proportions of households who have discussed about poultry husbandry in any areas where development agents could be met among the agro-ecological zones.

In the same way, there were no significant differences in relation to the proportions of respondents who had heard about improved poultry production practices and frequency of contacting development agents per month among agro-ecologies. However, the proportions of households using different sources of information regarding to improved poultry production practices were significantly different across the agro-ecological zones of the study area. Overall, the respondents replied that they met the development agents with the frequency of either a day per month (52.5%), two days per month (25.2%), three days per month (3.9%), four days per month (12.2%), five days per month (0.8%), a day per quarter (1.3%), a day per six month (0.8%), a day per year (0.3%), greater than six times per month (0.3%) and none at all (1%). Furthermore, all respondents (100%) obtained information about improved poultry production practices from both extension agents and radio (31.4%), extension agents and farmers (30.6%), extension agents (24.2%), extension agents and relatives (7%), extension agents, relatives and farmers (2.9%), relatives (1%), farmers (0.5%), extension agents, relatives and television (0.5%), radio (0.3%), neighbors (0.3%),extension agents, radio and neighbors (0.3%), extension agents , radio and television (0.3%), extension agents ,farmers and television (0.3%) and extension agents, relatives and neighbors (0.5%). This result was higher than that of Halima (2007) who reported that 70.6% of chicken growers obtained information about improved poultry production practices (such as exotic breeds) from market places, neighbors and extension officers in Northwest Ethiopia. This might be due to advancement of technology advertising Medias and Minister of Agriculture has given greater attention to improve village chicken productivity in Ethiopia.

Likewise, the survey also indicated that 68.8% of the respondents had been trained regarding to agricultural production interventions either of sole crop production (13%), dairy production only (0.3%), sole sheep production (0.3%), sole poultry production (1.3%), crop and poultry production (1%),dairy and crop production (0.3%), sheep ,goat and poultry production (0.3%),crop ,dairy ,sheep and goat production (42.6%),crop ,dairy ,sheep ,goat and poultry production (7.3%), crop, sheep and goat production (0.5%) or sheep and goat production (2.1%).While the remaining 29.4% of them had not been trained at all (Appendix table 5).

In the same way, the survey revealed that poultry production extension services had been given to 98.7% of the respondents in the study area (Appendix table 5). However, the proportions of households who had obtained poultry extension services were not significantly different among the agro-ecological zones of the study area. The poultry production extension services were given in either of advisory (77.4%), provision of improved chicks (0.8%), advisory and provision of improved chicks (19.7%), provision of improved chicks and feed (0.3%) or advisory ,provision of improved chicks and feeds (0.5%).

Table 24: Extension contact & services of households in three agro-ecologies of western Tigray

Variable	Agro- ecological zones				X2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Making discussion of poultry production & related problems with Extension agents					0.166(ns)	0.920
Yes	93(98.9)	130(99.2)	158(98.8)	381(99)		
No	1(1.1)	1(0.8)	2(1.2)	4(1)		
Meeting the extension agent at					4.309(ns)	0.166
Agent office	64(68.1)	86(65.6)	90(56.2)	240(62.3)		
Church	-	1(0.8)	5(3.1)	6(1.6)		
Agent office & farm house	24(25.5)	26(19.8)	38(23.8)	88(22.9)		
Agent office & Church	2(2.1)	2(1.5)	17(10.6)	21(5.5)		
Agent office , farm house & Church	3(3.2)	15(11.5)	8(5)	26(6.8)		
None	1(1.1)	1(0.8)	2(1.2)	4(1)		
Frequency of contacting the agent /month (days)					5.329(ns)	0.070
a day /month	50(53.2)	54(41.2)	98(61.2)	202(52.5)		
Two days /month	21(22.3)	51(38.9)	27(16.9)	99(25.2)		
Three days /month	3(3.2)	3(2.3)	9(5.6)	15(3.9 0		
Four days /month	15(16)	19(14.5)	13(8.1)	47(12.2		
Five days /month	1(1.1)	-	2(1.2)	3(0.8)		
>6 times/month	-	-	1(0.6)	1(0.3)		
a day/quarter	-	2(1.5)	3(1.9)	5(1.3)		
a day /six month	2(2.1)	-	1(0.6)	3(0.8)		
a day/year	1(1.1)	1(0.8)	4(2.5)	6(1.6)		
None	1(1.1)	1(0.8)	2(1.2)	4(1)		

* (p<0.05) and ns (p>0.05) and n=number of respondents interviewed per agro-ecology

4.2.2.9. Incubation, hatching, brooding and rearing practices

None of the respondents have used Solomon Hay Box Brooder for rearing chicks in the study area. Moreover, the respondents used broody hens for incubation but not artificial incubator. All respondents (100%) confirmed that they used broody hens for growing chicks (Table 25). However, Solomon Hay Box Brooder was only used when Minister of Agriculture distributed exotic breeds particularly RIR from 1998- 2000 E.C.

Egg Sources and Selection Practices and Egg Setting Materials: Farmers seem to have good practices of using egg-setting materials, which aimed at providing comfortable incubation environmental conditions for broody hens in the study area (Table 25). The survey revealed that the proportions of farmers who used different egg setting materials were significantly different among the agro-ecological zones of the study area ($p<0.05$). Overall, the respondents replied that they used either of clay pots with grasses (straw) bedding (1%), Ground with soil/sand/ash/cow dung/chopped grasses /straw/sand filled sack bedding (15.6%), Bin with grasses/straw/cotton seed/sand & feather of brooding hen/sack & sand /clothes/cow dung & straw/ bedding (68.8%), plastic with grasses (straw)/soil(sand)/soil or sand/ bedding (7.8%), Bamboo cages with soil and straw/teff straw/ breeding (0.3%), Bin (*ducon*) with grasses /straw/ bedding during rainy season & with sand bedding during dry season (3.9%), Cartoon with grasses and clothes bedding (0.8%), Dish with soil or clothes bedding (0.5%), Ground / Bin or dish with grasses bedding (0.3%) or Plastic and Bin with grasses /soil/ clothes bedding alternatively (1%) as egg setting materials in the study area (Table 25). In the lowland, farmers mostly used ground or bin or plastic with grasses or straw bedding as egg setting material during incubation in the rainy season with the perception of providing warm for both broody hens and eggs, and in the dry season, they commonly used ground or bin or plastic with sand or soil bedding and /or sack filled with dump soil or sand bedding as egg setting materials with the assumption of reducing temperature and increasing humidity of the incubation environment. In the same context, in both midland and highland agro-ecological zones, farmers mainly used bin or plastic with grasses or straws bedding as egg setting materials during incubation while they rarely used bin or plastic with soil or sand bedding as egg setting materials during the dry season. It seems a good practice but great care should be taken to keep eggs clean and not eggs become wet during setting materials preparation and egg storing in cold storage areas which may be favourable conditions for micro organisms to penetrate the shell and multiply inside the eggs and eventually spoil the egg, causing green, black and red rots (FAO, 2003). This result was in agreement with Tadelle *et al*. (2003b) who reported that clay pots, bamboo baskets, cartons or even simply a shallow depression in the ground are common materials and locations used as egg setting sites, and crop residues of Tef, wheat and barley straws were used as bedding materials in five different agro-ecological zones of Ethiopia.

Likewise, the result also showed that 39.2% of the respondents had practices of selection of eggs before incubation while the remaining 60.8% of them did not practice egg selection at all in the study area (Table 26). The proportions of households who had practiced or had not practiced selection of eggs for incubation were significantly different among the agro-ecologies. Generally, farmers selected eggs based on either of egg age (1.3%), egg type (9.9%), egg size (0.3%), egg age and type (19.2%), egg age, egg type and season (month) of egg laying (4.9%), egg age, egg type and size (3.1%) or egg type and size (0.8%). However, none of the households had selected eggs for incubation based on egg color (Table 26). In his study in Fogera district, Bogale (2008) also reported that 84.7% of the farmers selected large eggs followed by medium eggs (9.7%) and small sized eggs (1.4%) for incubation. Addisu *et al*. (2013) also recently reported that 88.24% of the village chicken owners of North Wollo zone had a practice of egg selection based on egg size and blood content. Season /month of egg laying was used as selection criteria for eggs selection only in the lowland but none of the households selected eggs for incubation based on this criteria in both midland and highland agro-ecologies. Because the annual temperature in the lowland areas ranges from 27^0c to 45 ^{0}c while the annual temperature in both midland and highland agro-ecologies ranges from 10^0c to 22 ^{0}c (Mekonnen *et al*., 2011). The optimum temperature for egg storage ranges from 12 ^{o}c to 26^oc (FAO, 2003; Kingori, 2011). The annual temperature in the lowland areas is greater than the optimum temperature for egg storage while in both midland and highland is within the range of optimum egg storages temperature. In the lowland, farmers replied that eggs stored for more than three days should not be used for incubation because most of them become spoiled. Farmers argued that successful hatchability of eggs can be achieved in the lowland if eggs are not stored more than two days and this is attained through collection of fresh eggs from all layers and incubate them by selected layer showing brooding behavior. Farmers in the lowland also responded that eggs stored for more than a week are not fitted for consumption because the quality of eggs is completely deteriorated due to extreme environmental temperatures. In both midland and highland agro-ecologies, farmers reported that eggs for hatching were stored until the time when the hen gets broody and ready to incubate but successful hatchability of eggs can be attained if they use eggs stored not more than a week. In Nigeria, eggs kept at high temperature of 40^{o}c deteriorated in quality very fast and were not fit for consumption after two weeks of storage, and in hot climate, where ambient temperature can reach 40-45^{o}c; eggs should not be stored at room temperature for more than one week before consumption (Raji *et al*., 2009). Moreover, reducing temperature marginally improved hatchability or egg viability in eggs stored for 9 to 11 days (Rulz *et al*., 2001).

Farmers practiced to sore eggs in either cold room (1.6%) or inside cold containers (98.4%) with the perception of improving the shelf lives of eggs in the study area (Table 26). Eggs are usually stored inside bins or other containers containing grains. Storage inside Noug, Cotton seed, Finger Millet and Tef were commonly practiced especially during dry season and is believed to increase humidity so as to increase the shelf lives of eggs and make them suitable for hatching ,sale or consumption. This result was in line with Tadelle *et al.* (2003b) who reported that household stored eggs inside grains especially Tef (*Eragrostis tef)* mainly practiced and believed to increase egg shelf lives in five different agro-ecological zones of Ethiopia. Most of the households (99.7%) positioned eggs sideways in the brooder hen while the remaining 0.3% of them positioned eggs pointed narrow end down in all agro-ecological zones of the study area

Furthermore, 5.5 % of the respondents had good experience of practicing special treatment of eggs before incubation while 94.5% of them did not practice any special treatment of eggs in the study area (Table 26). The survey revealed that there were significant variations with respect to the proportions of respondents who practiced or did not practice any special treatment of eggs across agro-ecologies. Overall, it was indicated that the respondents treated eggs with either of wash with cold water (0.8%), wash with warm water (0.3%) or clean eggs with clothes or other materials (4.4%). It is a good practice of incubating clean eggs but great emphasis should be taken towards keeping eggs not become wet during cleaning which ultimately create favorable conditions for microorganisms to enter and multiply inside the eggs and causing spoilage (FAO, 2003). Moreover, the households responded that their sources of eggs for incubation were either home laid eggs (91.2%), purchased from neighbors and home laid eggs (8.6%) or purchased from market and home laid eggs (0.3%) in the study area (Table 27).This result was in line with that of Meseret (2010) who reported that home laid eggs (80.6%), purchased from market and home laid eggs (13.9%) and purchased from market, neighbors and home laid eggs (5.6) were the major sources of eggs for incubation in Gomma wereda of Jimma zone. Matiwos *et al.* (2013) also reported similar findings in which lay at home (65.1%) and both lay at lay and purchase (34.9%) were used as sources of incubated eggs in Nole Kabba wereda of Western Wollega of Ethiopia.

Broody hen selection practices: In the same way, the respondents replied that they selected broody hens for incubation based on different selection criterias. Households selected brooding hens for incubation based on plumage color (97.7%), body weight (large size) (100%), broody behavior (100%) and mothering ability (100%) (Table 25). Farmers gave further emphasis in selecting better broody hens based on good hatching history (62.2%), good protector from predators /aggressive weaning the bird (0.3%), good hatching history and protector from predators /weaning the bird (30.9%), good feeder and hatching history (3.4%), good feeder, hatching history and protector from predators (2.6%) and good ability of setting, feeder, hatching history and protector from predators (0.3%) (Table 29). A study conducted in Fogera district disclosed that 66.7% and 19.4% of local chicken owners selected large and medium sized hens for incubation, respectively (Bogale, 2008). This result was also in parallel with the findings of Meseret (2010) which revealed that farmers selected hens for incubation based on either of large body size (21.1%), ample plumage /feather cover (3.3%), previous hatching history (6.7%), broodiness (19.4%) or large body size, ample plumage and previous hatching history (49%) in Gomma wereda of Jimma zone. Besides, the result of a survey conducted in North Wollo zone disclosed that 88.24% of village chicken owners had a practice of broody (Addisu *et al*., 2013).

Incubation Practices and Causes of Hatchability Failure: The respondents replied that they did not incubate eggs throughout the year and every season in the study area because of fluctuation of environmental conditions. The result indicated that there were significant variations in line with seasons of egg incubation across the agro-ecologies (Appendix table 6). Greatest proportions of respondents incubated eggs from June to February and June to March in midland (95.4% and 3.1%, respectively) in contrast with both lowland (85.6% and 0%) and highland (80.9% and 0%). Nevertheless, higher proportions of local chicken owners incubated eggs from June to January and September to June in lowland (13.8% and 0.6%) than midland (0.8% and 0%) but none of the respondents have incubated eggs during these months in highland because of poor survivability of young chicks due to heavy rains and extreme colds in highland. Maximum proportion of farmers incubated eggs from March to June (0.8%) and October to May (3.9%) in highland while none of the respondents incubated eggs in these specific months in both midland and lowland agro-ecologies. In general, the result showed that farmers mainly incubated eggs in June to February (87.8%) while September to June (0.3%), October to march (0.3%), June to march (1%), march to June (0.8%) and October to May (3.9%) were the worst months for egg incubation because of poor hatchability, due to high temperature and poor survivability of young chicks in March to May months especially in lowland, due to mud, heavy rains (extreme cold stress) in September to June in highland and disease outbreak and prevalence of predators in Spring.

Furthermore, the survey indicated that all respondents (100%) also replied that there was seasonal variability on the hatchability of eggs (Appendix table 6). It was also found that seasons (months) of both best and worst hatchability achievements were significantly different across agro-ecological zones of the study area ($p<0.05$). In lowland agro-ecology, worst hatchability of chickens mainly attained from March to May (95.6%) followed by February to May (4.4%). This might be due to the environmental temperature in the lowland extremely exceeds the optimum incubation temperature from March to May. The optimum incubation temperature of 37.8^{o}c is the thermal homeostasis in the chick embryo and gives the best embryo development and hatchability (Kingori, 2011). However, worst hatchability of chickens mostly achieved from march to may (95.4% and 80.9%) and followed by April to may (3.8%) and June to September(16%), respectively in midland and highland agro-ecologies of the area.

On the contrary, best hatchability of chickens mainly attained from June to February (80.9%) followed by October to May (16%) and June to March (3.2%) in the highland agro-ecology while best hatchability of chicken primarily achieved from June to February especially autumn (95.4%) followed by June to march (0.8%) and June to January (0.8%) in midland. In the lowland agro-ecology, respondents replied that best hatchability mainly attained from eggs incubated from June to February (86.9%) followed by June to January (12.5%) and October to march (0.6%). Generally, the households responded that lowest hatchability were mainly achieved from March to may (91.9%) followed by June to September (3.9%), February to May (2.1%) and April to May (2.1%). However, best hatchability of chickens were mostly attained from June to February especially autumn (88.3%) followed by June to January (5.5%), October to May (3.9%), June to march (1.8%) and October to march (0.5%) in the study area. In a study conducted in Fogera district, 81.9% and 26.4% of the households replied that the preferred season of incubation was dry and rainy season, respectively (Bogale, 2008).

The result showed that the respondents confirmed that temperature; lack of proper laying nest and post handling (99%), temperature and lack of proper post handling (0.5%), lack of proper laying nest and post handling (0.3%) and temperature (0.3%) were the major factors that cause failure of hatchability of chickens in the study area (Table 28).

Traditional Methods of Breaking Broodiness: Furthermore, the result of the study revealed that 97.4% of the total interviewed households used different traditional methods of breaking broodiness to increase egg production by stimulating broody hens to restart egg laying (Table 27). The traditional methods practiced by farmers of the study area and in their order of importance were moving to neighbors (30.1%), moving to neighbors (1^{st}) and hanging upside down (2^{nd}) (8.8%), disturbing in the nest (1^{st}) and Moving to neighbors (2^{nd}) (8.8%), hanging upside down (1^{st}) and moving to neighbors (2^{nd}) (8.6%), hanging upside down (8.3%), disturbing in the nest (5.7%), tying outside the original laying nest (5.5%), moving to neighbors (1^{st}) and tying outside the original laying nest (2^{nd}) (3.9%), tying both wings together (1^{st}) and moving to neighbors (2^{nd}) (3.4%), tying both wings together (3.1%), disturbing in the nest (1^{st}) and tying outside the original laying nest (2^{nd}) (1.6%), tying outside the original laying nest (1^{st}) and Moving to neighbors (2^{nd}) (1.6%), tying outside the original laying nest (1^{st}) and hanging upside down (2^{nd}) (1.3%), moving to neighbors (1^{st}) and disturbing in the nest (2^{nd}) (1%), tying outside the original laying nest (1^{st}) and disturbing in the nest (2^{nd}) (0.8%), hanging upside down (1^{st}) and tying both wings together (2^{nd}) (0.5%), hanging upside down (1^{st}) and tying outside the original laying nest (2^{nd}) (0.5%), tying both wings together (1^{st}), tying outside the original laying nest (2^{nd}) and moving to neighbors (3^{rd}) (0.5%), moving to neighbors (1^{st}) and tying both wings together (2^{nd}) (0.5%), separating broody hen from her chicks (0.5%), hanging upside down (1^{st}), tying both wings together(2^{nd}) and moving to neighbors (3^{rd}) (0.5%), disturbing in the nest (1^{st}) and hanging upside down (2^{nd}) (0.3%), disturbing in the nest (1^{st}) ,tying outside the original laying nest (2^{nd}) and moving to neighbors (3^{rd}) (0.3%), Piercing noise with sharp feather of broody hen for a week (0.3%), moving to neighbors (1^{st}), hanging upside down (2^{nd}) and disturbing in the nest (3^{rd}) (0.3%), tying plastic materials on legs of the broody hen (0.3%), moving to neighbors (1^{st}) and Separating broody hen from her chicks (2^{nd}) (0.3%), disturbing in the nest (1^{st}) and hanging upside down (2^{nd}) and Moving to neighbors (3^{rd}) (0.3%) (Table 27).This result was in parallel with the findings of Matiwos *et al.* (2013) who reported that piercing the nostril with a feather to prevent sitting, changing the hen's house/physically moving the hen to nearby house for a couple of days was found the most preferred practice implemented, hanging the hen upside down for a limited period of time each day for about 3-4 days and spraying water on hen's body and its place and also dipping broody hen in water were the brooding breaking techniques practiced in Nole Kabba Woreda of Western Wollega. Similarly, disturbing the broody hen in the nest (48.9%), hanging the hens upside down (18.9%), disturbing the broody hen in the nest, moving to neighbor (15.6%), disturbing the hens in the nest and moving to neighbor (7.8%),depriving the hens from food and water(5%) and, hanging the hens upside down and depriving the hens from food and water (2.2%) were the traditional methods of brea king broodiness practiced by the community of Gomma wereda (Meseret, 2010).This result also in lined with the findings of Nigussie (2011) and Nigussie *et al*. (2010b) who reported that hanging upside down (33%) and moving to neighbor houses (33%),submerge in to water up to the breast (1%),change brooding place (9) were the most important methods of breaking broodiness behavior of indigenous chickens in different parts of Ethiopia. Likewise, a report from North Wollo zone revealed that 96.73% of the village chicken owners had an experience of breaking broodiness behavior through either hanging upside down (65.2%), sending to neighbors (27.36%), preventing feed (4.73%) or showing broken egg (2.7%) (Addisu *et al*., 2013).

Indigenous Egg Fertility Testing Techniques: Farmers in the study area also seem to have good practice of testing eggs before incubation (Table 28). There were no significant variations with regard to the proportions of households who practiced testing of eggs prior to incubation across the agro-ecological zones of the study area. However, the distributions of different egg testing techniques practiced by the farmers were significantly different among the agro-ecological zones of the study area ($P<0.05$). Overall, the result of the survey revealed that 96.1% of the respondents tested eggs before incubation while the remaining 3.9% of them did not practice testing of eggs prior to incubation. The community based egg testing techniques practiced by the farmers of the study area and in their order of relevance were floating eggs in water (53.5%), shaking (14.8%), floating eggs in water (1^{st}) and shaking (2^{nd}) (14.5%), visual examination through sunlight (4.7%), visual examination through sunlight (1^{st}) and floating eggs in water (2^{nd}) (3.9%), visual examination through sunlight (1^{st}) and shaking (2^{nd}) (2.3%), floating eggs in water (1^{st}), visual examination through sunlight (2^{nd}) and shaking (3^{rd}) (0.8%), by coking sample eggs (0.5%), by breaking sample eggs (0.3%), floating eggs in water (1^{st}) and egg color change (change from white to bulla) (2^{nd}) (0.3%), by weighing eggs (0.3%) and floating eggs in water (1^{st}) and by coking sample eggs (2^{nd}) (0.3%). This result was in agreement with the findings of Matiwos *et al.* (2013) in which by shaking (47.8%), floating techniques (25%) and visual examination (27.2%) were commonly practiced techniques of normal eggs identification from spoiled ones prior to incubation in Nole Kabba Wereda of Western Wollega of Ethiopia. Similarly, Samson & Endalew (2010) reported that putting in water (28%), sun candling (39%) and shaking were used as methods of normal eggs identification from spoiled ones in Mid Rift Valley of Oromia of Ethiopia.

Table 25: Incubation, brooding practices, broody hen selection criterias and egg setting materials in three agro-ecological zones of Western Tigray

Variable	Agro- ecological zones				X2 -test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Incubation of eggs					0.00(ns)	1.00
Broody hen	94(100)	131(100)	160(100)	385(100)		
Brooding chicks					0.00(ns)	1.00
Broody hen	94(100)	131(100)	160(100)	385(100)		
Egg setting materials					68.437(*)	0.00
Clay pots with grasses (straw) bedding	1(1.1)	-	3(1.9)	4(1)		
Ground with soil/sand/ash/cow dung/chopped grasses /straw/sand filled sack bedding	2(2.1)	2(1.5)	56(35)	60(15.6)		
Bin(*ducon*) with grasses/straw/cotton seed/sand & feather of brooding hen/sack & sand /clothes/cow dung &straw	86(91.5)	107(81.7)	72(45)	265(68.8)		
Plastic with grasses (straw)/soil(sand)/soil or sand/ bedding	3(3.2)	15(11.5)	12(7.5)	30(7.8)		
Bamboo cages with soil and straw/teff straw/ breeding	-	-	1(0.6)	1(0.3)		
Bin (*ducon*) with grasses /straw/ bedding during rainy season & with sand bedding during dry season	-	2(1.5)	13(8.1)	15(3.9)		
Cartoon with grasses and clothes bedding	2(2.1)	-	1(0.6)	3(0.8)		
Dish with soil or clothes bedding	-	1(0.8)	1(0.6)	2(0.5)		
Ground / Bin(*ducon*)or dish with grasses bedding	-	-	1(0.6)	1(0.3)		
Plastic & Bin grasses /soil/ clothes bedding alternatively	-	4(3.1)	-	4(1)		
Broody hen selection criterias					9.391(*)	0.009
Plumage	128(97.7)	158(98.8)	380(98.7)	128(97.7)	2.238(ns)	0.327
Body weight	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Egg yield (production)	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Broody behavior	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Mothering ability	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Table 26: Egg selection criteria, egg positions in the brooder hens, egg storages and special egg treatment practice

Variable	Agro- ecological zones				X2 -test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Egg selection practice at time of /before incubation					14.49(*)	0.001
yes	36(38.3)	36(27.5)	79(49.4)	151(39.2)		
No	58(61.7)	95(72.5)	81(50.6)	234(60.8)		
Eggs selection criteria					21.936(*)	0.00
Egg age	1(1.1)	-	4(2.5)	5(1.3)		
Egg type	22(23.4)	9(6.9)	7(4.4)	38(9.9)		
Egg size	1(1.1)	-	-	1(0.3)		
Egg age & type	10(10.6)	21(16)	43(26.9)	74(19.2)		
Egg age, egg type and season/month of laying	-	-	19(11.9)	19(4.9)		
Egg age, egg type and size	1(1.1)	5(3.8)	6(3.8)	12(3.1)		
Egg type and size	2(2.1)	1(0.8)	-	3(0.8)		
Egg treatment practice before incubation					26.345(*)	0.00
Yes	-	1(0.8)	20(12.5)	21(5.5)		
No	94(100)	130(99.2)	140(87.5)	364(94.5)		
Ways of treating eggs					21.914(*)	0.00
Wash with cold water	-	-	3(1.9)	3(0.8)		
Wash with warm water	-	-	1(0.6)	1(0.3)		
Cleaning with clothes or other materials	1(1.1)	1(0.8)	15(9.4)	17(4.4)		
No treatment	93(98.9)	130(99.2)	141(88.1)	364(94.5)		
Egg color selection for incubation					0.00(ns)	1.00
Yes	-	-	-	-		
No	94(100)	131(100)	160(100)	385(100)		
Placement of eggs in the brooder hen					1.406(*)	0.495
Egg positions side ways	94(100)	131(100)	159(99.4)	384(99.7)		
Egg positions pointed narrow end down	-	-	1(0.6)	1(0.3)		
Storage of eggs					8.549(*)	0.014
Store in cold room	-	-	6(3.8)	6(1.6)		
Store inside cold containers	94(100)	131(100)	154(96.2)	379(98.4)		

* (p<0.05) and ns (p>0.05) and n=number of respondents interviewed per agro-ecology

Table 27: Practices to avoid broody behavior of chickens and sources of eggs for incubation

Practices	Agro- ecological zones				X2 -test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Methods of breaking of broody behavior					21.833(*)	0.00
Hanging upside down	4(4.3)	16(12.2)	12(7.5)	32(8.3)		
Disturbing in the nest	2(2.1)	3(2.3)	17(10.6)	22(5.7)		
Moving to neighbors	26(27.7)	64(48.9)	26(16.2)	116(30.1)		
Tying both wings together	4(4.3)	4(3.1)	4(2.5)	12(3.1)		
Tying outside the original laying nest	5(5.3)	1(0.8)	15(9.4)	21(5.5)		
Moving to neighbors (1^{st})& Disturbing in the nest(2^{nd})	1(1.1)	1(0.8)	2(1.2)	4 (1)		
Moving to neighbors (1^{st})& Hanging upside down (2^{nd})	9(9.6)	13(9.9)	12(7.5)	34(8.8)		
Tying both wings together(1^{st}) & Moving to neighbors(2^{nd})	4(4.3)	5(3.8)	4(2.5)	13(3.4)		
Nothing done	-	3(2.3)	7(4.4)	10(2.6)		
Tying outside the original laying nest(1^{st}) & Hanging upside down (2^{nd})	-	-	5(3.1)	5(1.3)		
Hanging upside down (1^{st}) & Moving to neighbors(2^{nd})	13(13.8)	9(6.9)	11(6.9)	33(8.6)		
Disturbing in the nest(1^{st}) & Moving to neighbors(2^{nd})	14(14.9)	1(0.8)	19(11.9)	34(8.8)		
Disturbing in the nest(1^{st}) & Hanging upside down (2^{nd})	-	-	1(0.6)	1(0.3)		
Disturbing in the nest(1^{st}) &Tying outside the original laying nest(2^{nd})	1(1.1)	-	5(3.1)	6(1.6)		
Disturbing in the nest(1^{st}) ,Tying outside the original laying nest(2^{nd}) & Moving to neighbors(3^{rd})	-	-	1(0.6)	1(0.3)		
Hanging upside down (1^{st}) & Tying both wings together(2^{nd})	-	1(0.8)	1(0.6)	2(0.5)		

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Table 27 (Continued)

Practices	Agro- ecological zones				X2 -test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Hanging upside down (1st) & Tying outside the original laying nest(2nd)	-	-	2(1.2)	2(0.5)		
Tying outside the original laying nest(1st) & Moving to neighbors(2nd)	1(1.1)	1(0.8)	4(2.5)	6(1.6)		
Moving to neighbors(1st) & Tying outside the original laying nest(2nd)	6(6.4)	3(2.3)	6(3.8)	15(3.9)		
Tying outside the original laying nest(1st) & Disturbing in the nest(2nd)	1(1.1)	-	2(1.2	3(0.8)		
Tying both wings together(1st), Tying outside the original laying nest(2nd) & Moving to neighbors(3rd)	1(1.1)	-	1(0.6)	2(0.5)		
Piercing noise with sharp feather of broody hen for a week	-	-	1(0.6)	1(0.3)		
Moving to neighbors(1st), Hanging upside down (2nd) & Disturbing in the nest(3rd)	-	-	1(0.6)	1(0.3)		
Moving to neighbors(1st) & Tying both wings together(2nd)	1(1.1)	-	1(0.6)	2(0.5)		
Tying plastic materials on legs of the broody hen for 3 or 4 days	1(1.1)	-	-	1(0.3)		
Separating broody hen from her chicks	-	2(1.5)	-	2(0.5)		
Hanging upside down(1st), Tying both wings together(2nd) & Moving to neighbors(3rd)	-	2(1.5)	-	2(0.5)		
Moving to neighbors(1st)& Separating broody hen from her chicks (2nd)	-	1(0.8)	-	1(0.3)		
Disturbing in the nest(1st) ,Hanging upside down(2nd) & Moving to neighbors(3rd)	-	1(0.8)	-	1(0.3)		
Sources of eggs for incubation					4.643(ns)	0.098
Laid at home	89(94.7)	114(87)	148(92.5)	351(91.2)		
Purchased from neighbors & laid at home	5(5.3)	16(12.2)	12(7.5)	33(8.6)		
Purchased from market & laid at home	-	1(0.8)	-	1(0.3)		
Do you incubate eggs purchased from market?					1.939(ns)	0.379
Yes	-	1(0.8)	-	1(0.3)		
No	94(100)	130(99.2)	160(100)	384(99.7)		

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Table 28: Major causes of hatchability failure and fertility testing techniques of eggs before incubation

Variable	Agro-ecological zones				X2 -test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Eggs testing practice before incubation					1.939(ns)	0.379
Yes	89(94.7)	125(95.4)	156(97.5)	370(96.1)		
No	5(5.3)	6 (4.6)	4(2.5)	15(3.9)		
Egg fertility testing techniques					28.059(*)	0.000
Visual examination through sunlight	7(7.4)	4(3.1)	7(4.4)	18(4.7)		
Floating eggs in water	21(22.3)	84(64.1)	101(63.1	206(53.5		
Shaking	26(27.7)	22(16.8)	9(5.6)	57(14.8)		
Floating eggs in water(1^{st}) &shaking(2^{nd})	32(34)	7(5.3)	17(10.6)	56(14.5)		
Visual examination through sunlight(1^{st}) and shaking (2^{nd})	2(2.1)	1(0.8)	6(3.8)	9(2.3)		
Floating eggs in water(1^{st}), Visual examination through sunlight(2^{nd}) and shaking (3^{rd})	-	-	3(1.9)	3(0.8)		
By coking sample eggs	-	1(0.8)	1(0.6)	2(0.5)		
By breaking sample eggs	-	1(0.8)	-	1(0.3)		
Floating eggs in water(1^{st}) and egg color change (2^{nd})	-	1(0.8)	-	1(0.3)		
By weighing eggs	-	1(0.8)	-	1(0.3)		
Visual examination through sunlight(1^{st}) and floating eggs in water (2^{nd})	-	3(2.2)	12(7.5)	15(3.9)		
Floating eggs in water(1^{st}) & by coking sample eggs (2^{nd})	1(1.1)	-	-	1(0.3)		
Nothing done	5(5.3)	6(4.6)	4(2.5)	15(3.9)		
Major causes of failure of hatching					1.417(ns)	0.492
Lack of proper laying nest & post handling	-	-	1(0.6)	1(0.3)		
Temperature & Lack of proper laying nest & post handling	94(100)	131(100)	156(97.5)	381(99)		
Temperature	-	-	1(0.6)	1(0.3)		

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

4.2.2.10. Breeding and culling practices

The survey revealed that the proportions of farmers who practiced control and uncontrolled mating systems were significantly different among the agro-ecological zones of the study area ($p<0.05$) (Table 29). Higher proportions of chicken owners had practiced control mating in lowland (7.5%) than midland (1.5%) but none of the respondents had practiced control mating system in highland. Nevertheless, greatest proportions of respondents had practiced uncontrolled mating system (100%) in highland in comparison with both midland (98.5%) and lowland (92.5%). Overall, the survey disclosed that 3.6% of the respondents had practiced control mating while the remaining 96.4% of them had practiced uncontrolled mating system because of free scavenging production system.

On the contrary, the proportions of chicken owners who practiced different ways of mating control were not significantly different across the agro-ecological zones. Generally, culling poor productive (43.9%) was the first most frequent way of mating control of farmers ‘flock followed by retaining best cocks and layers for further breeding (36.9%), cull at early age (13.2%) and preventing mate (6%) in the study area (Table 29). Similarly, this result was somewhat comparable with the findings of Addisu *et al*. (2013) in North Wollo zone of Amhara Regional state which revealed that 89.2% of village chicken owners had uncontrolled natural mating system while 10.79% of them had practiced mate control of their flocks through either retaining best indigenous or exotic cocks with layers (52.79%), preventing mate (24.37%), cull at early age (19.19%) or culling poor productive (3.55%). However, this result contradicted with the findings of Nigussie *et al*. (2010b) and Nigussie (2011) which revealed that there was no systematic mating system in any regions of Ethiopia. In another study conducted in Dale, Wonsho and Loka Abaya weredas of SNNPRS revealed that free-range feeding practice attributed to indiscriminate mating of cocks and hens (Mekonnen, 2007).

Besides, the survey also showed that only 1% of the respondents had an inbreeding concept while the remaining 99% of them had not an inbreeding concept and they replied that the word inbreeding was a new term for them. Agro-ecological wise, 100% of the respondents in both highland and midland agro-ecologies had not totally an inbreeding concept. However, 2.5% of the respondents in lowland agro-ecology had an inbreeding concept while 97.5% of them had explained the inbreeding concept was new for them and they had not known it before.

Furthermore, the result of the study indicated that all respondents (100%) had a good experience of culling less productive purposely in the study area (Table 30). It was also found that the proportions of village chicken owners who culled their less productive chickens through different means of culling were significantly different among the agro-ecological zones of the study area ($p<0.05$). Slaughtering for consumption (64.9%), consumption and selling (24.7%) and selling (10.4%) were the predominant means of culling poor productive chickens from their flock. (Table 30).This result showed an agreement with the findings of Addisu *et al*. (2013) who reported that slaughtering (53.27%), selling (41.18%) and consumption or selling eggs of unwanted hens (5.56%) were the major means of culling less productive chickens in North Wollo zone.

The analysis of breeding practices showed that there were no significant variations with respect to the proportions of respondents who had breeding practices, methods of breeding and ways of improving indigenous chickens across the agro-ecological zones of the study area($P>0.05$) (Table 30). In general, the result revealed that 99.7% of the respondents had breeding practices for improving productivity of their flocks either by improving indigenous chickens (99.5%) or by importing exotic breeds (0.5%). Moreover, village chicken owners had also a practice of improving the productivity of their indigenous flocks either by crossbreeding (10.4%) , by line breeding (86.2%) or both cross and line breeding (3.4%) (Table 29). However, contrasting results have been reported from Gomma wereda o f Jimma zone which stated that village chicken production system was characterized by lack of systematic breeding practices in the district (Meseret, 2010).Moreover, the result of the study conducted by Nigussie (2011) in different part of Ethiopia revealed that village chicken breeding was completely uncontrolled and replacement stock produced through natural incubation using broody hens. In a study recently conducted by Addisu *et al.* (2013) in North Wollo zone of Amhara regional state indicated that only 17.3% of village chicken producers had breeding practices in improving their chicken either by cross breeding (80%) or by line breeding (20%).

The analysis of chicken selection practices of the village chicken producers revealed that all of the respondents (100%) had practices of chicken selection for breeding and production in the study area (Table 29). It was also found that the proportions of farmers who had practiced selection of chickens were not significantly different across the agro-ecological zones of the study area. Generally, the result disclosed that plumage color (98.7%), body weight (heavier) (100%), egg yield (high yielder) (100%), broody behavior(slow brooding behavior) (100%), mothering ability (100%), sex (both male and female)(100%) and comb type (98.4%) were used as selection criteria for selecting chickens for breeding and production purposes. Specifically, the result indicated that 98.2% the respondents ranked the plumage colors and ordered them in their preferences were red (1^{st}), *gebsima* (*Sigemo*) (2^{nd}), *Anbesima* (3^{rd}), *Kokima* (4^{th}), *Zagrama* (5^{th}), *Netch Teterma* (6^{th}), *key Teterma* (7^{th}), *seran* (8^{th}) , black *Teterma* (9^{th}), *Netch* (10^{th}) and black (11^{th}) while the remaining 0.5% of them preferred three types plumage colors and ranked these plumage colors in their degree of preference were red(1^{st}), *gebsima* (2^{nd}) and *Anbesima* (3^{rd}).

Furthermore, the respondents gave due attention to mothering ability characteristics of hens while broody hens were selected for incubation purposes. It was indicated that most of village chicken owners selected breeding females based on previous hatching history (62.2%) followed by both good hatching history and protector from predators (30.9%), good feeder and protector from predators (3.4%), good feeder, hatching history and protector from predators (2.6%), good ability of setting, feeder, hatching history and Protector from predators (0.3%) and good protector (0.3%) (Table 29). In the same way, 97.4% of the respondents preferred to retain chickens with double comb types (rose and pea) while 0.5% of them favored to maintain chickens with single comb types for breeding and production purposes in the study area. This result was in parallel with the findings of Bogale (2008) who reported that 94.4 % of village chicken producers practiced chicken selection based on different selection criteria like sex, plumage color, egg production and growth in Fogera district.

This result also slightly corroborated the findings of Al-Qamashoui *et al*. (2014) who reported that egg production (1st), body size and growth rate (2nd), Feather (plumage) color (3rd), body conformation (4th) and egg size (5th) were the major traits used as selection criterias for selecting breeding chickens in a given flock in six major agro-ecological zones of Oman.

The analysis of culling practices of village chicken owners disclosed that all respondents (100%) had practices of culling chickens purposely from their flocks at any time in the study area (Table 30). The result of the study revealed that the proportions of respondents who had a practices of culling chickens with different determinant culling factors were not significantly different across the agro-ecologies ($p>0.05$). However, the proportions of households who used culled chickens for different purposes were significantly variable among the agro-ecological zones of the study area ($p<0.05$).

Poor productivity (47.3%), poor productivity and sickness (22.9%), poor productivity, old age and sickness (17.7%), poor productivity and old age (6%), lack of broodiness (2.1%), old age (1.6%), poor productivity and lack of broodiness (1.6%) and sickness (1%) were the major determinant factors for culling unwanted chickens from a given flock of village chicken producers in the study area (Table 30). This result was somewhat comparable with the findings of Meseret (2010) who reported that sickness (36.1%), frequent broodiness (22.8%), sickness and old age (12.2%), lack of broodiness (8.3%), old age (7.2%) and lack of broodiness and frequent broodiness (5.6%) were the major factors for culling wanted chickens from the flocks of farmers in Gomma wereda of Jimma zone.

According to the survey, about 27% of the respondents had culled chickens from their flock based on chicken age and while 73% of them did not cull chickens based on chicken age in the study area. The result revealed that 13% of the respondents culled chickens whose age was greater than three years while the remaining 13 % of them culled chickens when their age exceeded four years and 1% of the respondents culled chicken when their age exceeded five years (Table 30). Moreover, only 42% of the respondents culled chickens by using sickness as specific culling factor of chickens from their flock.

Moreover, the survey also showed that the village chicken producers used the culled chickens for the purposes of slaughtering for consumption (64.9%), slaughtering and selling (24.7%) and selling for income generation (10.4%) in the study area (Table 34). Besides, highest proportions of chicken owners used culled chickens for slaughtering in midland (82.4%) in relation to both highland (58.5%) and lowland (54.4%) agro-ecologies. Nevertheless, greatest proportions of households used culled chickens for selling, slaughtering and selling in lowland (12.5% and 33.1%, respectively) as compared to both highland (10.6% and 30.9%) and midland (7.6% and 9.9%).This result corroborated the findings of Addisu *et al*. (2013) who reported that slaughtering (53.27%), selling (41.18%) and consume or sell eggs of unwanted hens(5.56%) were the major means of culling less productive chickens from a flock in North Wollo zone of Amhara regional state. However, this result was slightly different from the findings of Bogale (2008) who reported that home consumption and selling were the main culling means of poor productive chicken (46.5%), old age and poor productive (25%) and sickness (5.65%) chicken from the flock in Fogera district. In the same way, farmers cull poor productive and old age chickens through selling in Northwest Ethiopia (Halima, 2007) and Fisseha (2009) also reported that selling and home consumption (62.6%) were the most predominant methods of culling unproductive chicken from a flock in Bure dist rict.

People may become ill if they eat products of sick chicken (egg & meat). Because poultry zoonoses are infections passed from chickens to humans and cause severe health problems. Transmission of diseases (such as Salmonella, Campylobacter, E-coli, Chlamydophilo psittaci, Avain influenza and others) may result from direct contact with a diseased chicken, contaminated poultry litter or through consumption of contaminated poultry products (http://www.fao.org/AVIANFLU/EN/qanda.html). It is strongly recommended that farmers should never eat sick or dead chickens nor sell them to others. Chicken producers should use gloves and boots when handling sick and dead chickens. Carcass of dead chickens should not be thrown in to rivers, lakes or other bodies of water, and not fed them to dogs, cats or other animals. Dead chickens should be burned or buried safely away from farmers' farm yards and deeply enough so that dogs, cats and other scavengers cannot reach them. Feathers and other wastes (droppings) should be burned or buried properly.

Table 29: Mating system and practices, breeding methods, inbreeding concept and selection criteria for chicken breeding

Variable	Agro- ecological zones					
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)	X2-test	p-value
Mating system					11.996(*)	0.002
Control mating	-	2(1.5)	12(7.5)	14(3.6)		
Uncontrolled mating	94(100)	129(98.5)	148(92.5)	371(96.4)		
Ways of mating for improvement					2.319(ns)	0.314
Culling poor productive	37(39.4)	56(42.7)	76(47.5)	169(43.9)		
Cull at early age	10(10.6)	20(15.3)	12(13.1)	51(13.2)		
Retaining of best ones	41(43.6)	46(35.1)	55(34.4)	142(36.9)		
Preventing mating	6(6.4)	9(6.9)	8(5)	23(6)		
Breeding practice					1.406(ns)	0.495
yes	94(100)	131(100)	159(99.4)	384(99.7)		
no	-	-	1(0.6)	1(0.3)		
Breeding methods					0.674(ns)	0.714
Importing exotic	-	1(0.8)	1(0.6)	2(0.5)		
Improving indigenous	94(100)	130(99.2)	159(99.4)	383(99.5)		
Ways of improving indigenous chickens					3.118(ns)	0.210
Cross breeding	5(5.3)	9(6.9)	26(16.2)	40(10.4)		
Line breeding	89(94.7)	118(90.1)	125(78.1)	332(86.2)		
Both	-	4(3.1)	9(5.6)	13(3.4)		
Chicken selection practice for breeding & production					0.00(ns)	1.00
yes	94(100)	131(100)	160(100)	385(100)		
no	-	-	-	-		
Selection criteria						
Plumage color					2.238(ns)	0.327
Yes	94(100)	128(97.7)	158(98.8)	380(98.7)		
No	-	3(2.3)	2(1.2)	2(1.3)		

* (p<0.05) and ns (p>0.05) and n=number of respondents interviewed per agro-ecology

Table 29 (Continued)

	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)	X2-test	p-value
Rank of plumage colors on basis of prefer.					1.544(ns)	0.462
Red(1st),*Gebsima* (2nd), *Anbesima* (3rd), *Kokima* (4th), *Zagrama* (5th), *Netch Teterma* (6th), *key Teterma* (7th), *Seran* (8th), black *Teterma* (9th), *Netch* (10th) & black(11th)	93(98.9)	128(97.7)	157(98.1)	378(98.2)		
Red(1st), *Gebsima* (2nd) & *Anbesima* (3rd)	1(1.1)	-	1(0.6)	2(0.5)		
Body weight	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Heavy	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Egg yield (production)	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Broody behavior	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Slow brooding behavior	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Mothering ability	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Preference of mothering ability characteristics					9.391(*)	0.009
Good hatching history	50(53.2)	79(60.3)	112(70)	241(62.2)		
Good protector from predators / aggressive weaning	-	-	1(0.6)	1(0.3)		
Good hatching history & good protector from predators / aggressive weaning the bird	44(46.8)	34(26)	41(25.6)	119(30.9)		
Good feeder & hatching history	-	10(7.6)	3(1.9)	13(3.4)		
Good feeder ,hatching history &protector from predators	-	8(6.1)	2(1.2)	10(2.6)		
Good ability of setting ,feeder ,hatching history & protection from predators	-	-	1(0.6)	1(0.3)		
Comb type					3.598(ns)	0.16
Yes	92(97.9)	126(96.2)	159(99.4)	377(97.9)		
No	2(2.1)	5(3.8)	1(0.6)	8(2.1%)		
Preference of comb types					2.776(ns)	0.250
Single	-	1(0.8)	1(0.6)	2(0.5)		
Double	92(97.9)	125(95.4)	158 (98.8)	375(97.4)		
Sex (both male & female)	94(100)	131(100)	160(100)	385(100)	0.00(ns)	1.00
Inbreeding concept					5.669(ns)	0.059
Yes	-	-	4(2.5)	4(1)		
No	94(100)	131(100)	156(97.5)	381(99)		

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Table 30: Culling practices, culling purposes, determinant factors which bird/s will cull

Parameters	Agro- ecological zones					
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)	X2-test	p-value
Culling chickens purposely at any time					0.0(ns)	1.00
yes	94(100)	131(100)	160(100)	385(100)		
no	-	-	-	-		
Chicken culling purposes					28.589(*)	0.00
Consumption (slaughter)	55(58.5)	108(82.4)	87(54.4)	250(64.9)		
sell	10(10.6)	10(7.6)	20(12.5)	40(10.4)		
Consumption and sell	29(30.9)	13(9.9)	53(33.1)	95(24.7)		
Determinant factors for culling					5.059(ns)	0.50
Poor productivity	58(61.7)	47(35.9)	77(48.1)	182(47.3)		
Old age	-	-	6(3.8)	6(1.6)		
Sickness	-	3(2.3)	1(0.6)	4(1)		
Lack of broodiness	2(2.1)	6(4.6)	-	8(2.1)		
Poor productivity & old age	1(1.1)	12(9.2)	10(6.2)	23(6)		
Poor productivity & sickness	9(9.6)	43(32.8)	36(22.5)	88(22.9)		
Poor productivity & lack of broodiness	-	6(4.6)	-	6(1.6)		
Poor productivity, old age & sickness	24(25.5)	14(10.7)	30(18.8)	68(17.7)		
what age of the bird do you decide to cull it					8.14(*)	0.017
>3 year	18(19.1)	11(8.4)	21(13.1)	50(13)		
>4 year	7(7.4)	15(11.5)	28(17.5)	50(13)		
>5 year	-	-	4(2.5)	4(1)		
Birds not culled based on their age	69(73.4)	105(80.1)	107(66.9)	281(73)		

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Table 30 (Continued)

Parameters	Agro- ecological zones					
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)	X2-test	p-value
If sickness is a factor for culling a bird ,when do you cull it					0.00(ns)	1.00
Avoid expected disease outbreak	-	-	-	-		
When the bird is already sick	35(37.2)	60(45.8)	69(43.1)	164(42.6)		
Trend of the clutch period as the age of hen increases					0.00(ns)	1.00
Increase	-	-	-	-		
Decrease	94(100)	131(100)	160(100)	385(100)		
When the pullet is supposed to set eggs for hatching chicks					13.992(*)	0.001
1st clutch	30(31.9)	74(56.5)	84(52.5)	188(48.8)		
2nd clutch	63(67)	57(43.5)	71(44.4)	191(49.6)		
3rd clutch	1(1.1)	-	1(0.6)	2(0.5)		
2nd and 3rd clutch	-	-	2(1.2)	2(0.5)		
In 1st clutch with reduced number of eggs	-	-	2(1.2)	2(0.5)		

* ($p<0.05$) and ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

4.2.2.11. Breeding objectives and trait preference

Th pooled analysis of ranking indices of breeding objectives in indigenous chickens from both the survey and Focus group discussion has showed variability across agro-ecological zones (Table 31). The keeping of chickens for sales seems the first priority that demonstrates the change from traditional (subsistence) to market oriented production system of chickens in the villages. This could be attributed to high market channel in the local community fueled by high cash crop production such as sesame and cotton, and cross border market opportunities to the Sudan in the west and to Eretria in the North. Moreover, this may be due to the increase in the population density of the area as many peoples and investors from different corners of Ethiopia as well as from Sudan are always flowing to this area to engage in different investment areas. Furthermore, some investors from Eritrea, Nigeria and Senegal are living and engaging in different investment areas of the study area because the area is the investment zone of Tigray region. The establishment of Welkait National Sugar Factory in Mezega area of Maygeba wereda may also be a factor for population density increment which consequently increases poultry products' demand in the area. The breeding objectives in the village chicken production is meant to address multiple objectives through designing and implementing community- based and environmentally friendly holistic and sustainable genetic improvement strategies .The rank of breeding objectives across agro-ecologies was variable (Table 31). In highland agro-ecology, farmers mainly reared chickens primarily for sales for income (1st), Ceremony (2nd) and home consumption (3rd) while chickens mainly reared for ceremony (1st), home consumption and ceremony (2nd) and sales for income (3rd) in the midland agro-ecology (Table 31). On the other hand, chickens primarily reared for sales for income (1st), ceremony and sales for income (2nd) and home consumption and ceremony (3rd) in the lowland agro-ecology (Table 31).

Likewise, this result was somewhat equivalent with the findings of Fisseha *et al*. (2010) revealed that sales for income (51%), hatching (breeding) (45%), and home consumption (44%), ceremony (36.4%) and egg production (40.7%) were the rearing purposes of chickens in Bure district. In the same way, Addisu *et al*. (2014) recently also reported that home consumption (30.4%), replacement (23.18%) and market reasons (18.1%) were the first, second and third main rearing purposes of chickens in North Wollo Zone of Amhara regional state. In Northern Gondar, home consumption and income (82%), home consumption and replacement (46%) and sources of income (37%) were identified as main poultry production objectives of local chicken owners (Wondu *et al*., 2013). Similarly, Solomon *et al*. (2013) reported cash income (98.6%), household consumption (95.2%), extra farm activity (82.8%), job opportunity (60%), use of chicken for cultural/religious ceremonies (39.3%) and to use them as gift (20%) were the main purposes of chicken production in Metekel Zone of Northwest Ethiopia. Moreover, Petrus (2011) reported that home consumption (46.1%), custom (42.3%), income (9.6%) and Sacrifices (1.9%) were the main chicken breeding purposes of keeping indigenous chickens in four regions (Oshana,Omusati,Ohangwena and Kavango) of Northern Namibia. Nassim *et al*. (2011) also reported that meat production (96.2%, 100% and 90.9%), tradition (88.5%, 73.3% and 72.7%), food security (73.1%, 86.7% and 54.6%) and egg production (19.2%, 40% and 9.1%) were the main objectives of keeping the Ri chicken breed in the Ky-son,Luong-son and Gia-Lam districts of North Vietnam respectively. In a study conducted in Uganda, home consumption (36%), cash (33%), ceremonies (16%) and gifts (13%) were found to be the main purpose of keeping indigenous chickens and indigenous eggs were mainly used for hatching chicks (45%), eaten at home (33%), sale for cash (20%) and 2% are used other purposes (Ssewannyana *et al*., 2008). The diversity in breeding objectives in different agro-ecologies shows the need to plan a breeding strategy that suits the market demand and farmers preferences. However, setting a breeding program to address multiple objectives may complicate the method of evaluation and infrastructure which in turn necessitated the need to focus on two or three priority breeding objectives.

The analysis of ranking indices of the trait preferences of chicken producers from both respondents and focus group discussion indicated no variability across agro-ecological zones even if production environments are heterogeneous (Table 32). This confirms that farmers across agro-ecologies have nearly used homogeneous attributes in selecting best breeding chickens from their flock for achieving their production objectives. Generally, plumage color (1st), egg yield /clutch (2nd), comb type (3rd) and body weight (growth) (4th) were the most preferred traits used for selection of breeding chickens in all agro-ecological zones of the study area (Table 32). Plumage color was the first most preferred traits in choosing breeding chickens in all agro-ecological zones. Red, *gebsima* and *anbesima* colored chickens in that order are most preferred to chickens with other plumage colors while black and white colored chickens are the least favoured for breeding and consumption (Table 32). Chickens with the order of red, *gebsima* and *anbesima* plumage colors have high market demand while black and white colored chickens are undesired on market across all agro-ecologies. All respondents in all agro-ecologies of the study area also perceive that the plumage color of chicks is inherited from the plumage color of breeding cock and hence farmers gave highest emphasis for plumage color of cocks during selection for breeding purpose. Due to this reason, farmers gave greatest emphasis for egg yield /clutch performances of breeding females (hens) during selection for breeding. Comb type was the third most preferred attribute for selection of breeding chickens in all agro-ecologies (Table 32). Chickens with double comb (pea and rose) types are highly preferred to single combed chickens for breeding (Table 32) and the former has higher market demand while the latter has less preferred in the market. This result was somewhat parallel with the findings of Addisu *et al*. (2013) in which number of egg production/clutch (37.91%) and plumage color (37.58%) were the major preferred traits in North Wollo zone, and plumage color (44.34%) was the primarily selected traits in the lowland while egg (46%) was selected as primarily trait in the highland. However, Comb type and plumage color were found to most preferred traits in Fogera district (Bogale, 2008) and in Bure district of North West Ethiopia (Fisseha *et al.*, 2010). Nigussie (2011) also reported that farmers mainly selected adaptive traits, meat and egg test as their preferred traits in different parts of Ethiopia. Moreover, growth rate, disease tolerance, egg yield, body size and fertility were the most important preferred traits of chicken producers in Jordan (Abdelqader *et al*., 2007). In Kenya, egg yield (1st), mothering ability (2nd) and body size (3rd) were the most preferred traits by majority Kenyan chicken farmers (Okeno *et al.*, 2010). Identification of trait preferences of chicken producers under scavenging production system is one step ahead in developing successful and sustainable chicken breeding strategies. Thus, designing and developing of sustainable breeding programs for genetic improvement of indigenous chickens should incorporate trait preferences of chicken owners and address the current and future market circumstances in order to enhance sustainable improved chicken productivity.

Regarding to the traits preferred to be improved through breeding interventions, the pooled analysis of both ranking indices of the respondents from the survey (Table 33) and Focus group discussion revealed that there were no differences in the desire traits to be improved through breeding. Overall, Egg laid/clutch (1st), body weight (growth) (2nd), adaptation (3rd), reproduction (hatching) (4th), plumage color (5th), mothering ability (6th), comb type (7th), smoothness of legs (shank) (8th), length of legs (9th) and shank color (10th) were the major preferred traits to be improved through breeding in the study area (Table 33). This result was comparable with the reports of Addisu *et al*. (2013) in which egg production /hen, meat yield and disease resistance were the farmers' preferred traits to be improved through breeding in North Wollo Zone of Amhara regional state of Ethiopia. Moreover, Abdelqader *et al.* (2007) also reported that hatchability, survivability, flock size, number of clutches, egg weight and egg mass of local chickens were the major traits improved significantly with improvement in management levels in the rural areas of northern districts of Jordan.

Table 31: Ranking of breeding objectives in three agro-ecological zones of Western Tigray

Highland agro-ecology												
Objectives	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Sales for income	48	14	20	12	0	0	0	0	0	0	0	0.1522
Ceremony	26	36	10	22	0	0	0	0	0	0	0	0.1470
Home consumption	12	20	22	30	10	0	0	0	0	0	0	0.1354
Hatching/breeding	8	15	18	16	28	9	0	0	0	0	0	0.1254
Home consumption and ceremony	0	9	14	8	20	30	8	5	0	0	0	0.1064
Home consumption and sales for income	0	0	4	2	10	22	40	12	4	0	0	0.0829
Ceremony and sale for income	0	0	3	1	6	12	20	42	10	0	0	0.0721
Breeding and home consumption	0	0	2	1	6	10	12	20	40	3	0	0.0635
Ceremony and breeding	0	0	1	1	5	8	10	10	20	36	3	0.0524
Breeding and sales for income	0	0	0	1	8	1	4	3	12	30	36	0.0377
Breeding ,home consumption ,sales for income and ceremony	0	0	0	0	1	2	0	2	6	25	59	0.0248
Midland agro-ecology												
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Ceremony	46	40	38	7	0	0	0	0	0	0	0	0.1512
Home consumption and ceremony	40	34	37	20	0	0	0	0	0	0	0	0.1476
Sales for income	36	42	32	21	0	0	0	0	0	0	0	0.1475
Hatching/breeding/	9	6	10	35	40	20	11	0	0	0	0	0.1141
Ceremony and sales for income	0	3	4	20	30	32	20	12	10	0	0	0.0934
Breeding and home consumption	0	2	5	10	20	36	18	14	12	14	0	0.0801
Home consumption	0	2	2	10	12	32	16	8	26	14	9	0.0720
Ceremony and breeding	0	2	3	6	10	5	25	43	20	9	8	0.0670
Home consumption and sales for income	0	0	0	2	8	4	19	22	28	42	6	0.0525
Breeding and sales for income	0	0	0	0	6	1	12	18	20	30	44	0.0399
Breeding ,home consumption ,sales for income and ceremony	0	0	0	0	5	1	10	14	15	22	64	0.0348

* R1, R2, R3---R11=Rank 1, 2, 3, 4----11 respectively.

Index=sum of (11 for Rank1 +10 for Rank2 +…+1for Rank 11) given for each trait divided by the sum of (11for Rank1 +10 for Rank2 +…+1for Rank 11) for all traits under consideration

Table 31 (continued)

Objectives	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Lowland agro-ecology												
Sales for income	80	47	20	13	0	0	0	0	0	0	0	0.1547
Ceremony and sales for income	50	30	27	23	18	12	0	0	0	0	0	0.1397
Home consumption and ceremony	20	45	27	26	14	10	9	9	0	0	0	0.1288
Home consumption and sales for income	10	32	29	20	16	12	15	20	6	0	0	0.1144
Hatching /breeding	0	6	18	21	50	10	16	22	8	9	0	0.0956
Ceremony	0	0	14	18	26	35	18	15	20	12	2	0.0850
Ceremony and breeding	0	0	10	18	30	29	20	16	21	10	6	0.0825
Breeding and home consumption	0	0	8	**7**	6	24	36	42	20	12	5	0.0711
Home consumption	0	0	5	6	0	16	34	36	54	6	3	0.0644
Breeding and sales for income	0	0	2	5	0	10	12	0	18	80	33	0.0402
Breeding ,home consumption ,sales for income and ceremony	0	0	0	3	0	2	0	0	13	31	111	0.0235
Western zone of Tigray												
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Sales for income	164	103	72	46	0	0	0	0	0	0	0	0.1513
Ceremony	72	76	62	47	26	35	18	15	20	12	2	0.1223
Home consumption	12	22	29	46	22	48	50	44	80	20	12	0.0857
Hatching/breeding	17	27	46	72	118	39	27	22	8	9	0	0.1089
Home consumption and ceremony	60	88	78	54	34	40	17	14	0	0	0	0.1294
Home consumption and sales for income	10	32	33	24	34	38	74	54	38	42	6	0.0855
Ceremony and sale for income	50	33	34	44	54	56	40	54	20	0	0	0.1072
Breeding and home consumption	0	2	15	18	32	70	66	76	72	29	5	0.0729
Ceremony and breeding	0	2	14	25	45	42	55	69	61	55	17	0.0697
Breeding and sales for income	0	0	2	6	14	12	28	21	53	140	109	0.0396
Breeding ,home consumption ,sales for income and ceremony	0	0	0	3	6	5	10	16	34	78	234	0.0276

* R1, R2, R3---R11=Rank 1, 2, 3, 4----11 respectively.

Index=sum of (11 for Rank1 +10 for Rank2 +…+1for Rank 11) given for each trait divided by the sum of (11for Rank1 +10 for Rank2 +…+1for Rank 11) for all traits under consideration.

Table 32: Ranking of trait preference of chicken producers in three agro-ecological zones of Western Tigray

Lowland agro-ecology												
Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Plumage color	137	0	10	0	0	13	0	0	0	0	0	0.1586
Comb type	0	95	0	37	23	0	1	0	0	4	0	0.1345
Egg laid/clutch	10	55	95	0	0	0	0	0	0	0	0	0.1435
Body weight /growth	13	10	42	95	0	0	0	0	0	0	0	0.1308
Reproduction/hatching	0	0	13	15	132	0	0	0	0	0	0	0.1099
mothering ability	0	0	0	0	5	132	13	0	0	10	0	0.0864
Adaptation	0	0	0	13	1	14	132	0	0	0	0	0.0810
Length of legs	0	0	0	0	0	0	4	155	1	0	0	0.0609
Shank color	0	0	0	0	0	0	10	5	145	0	0	0.0478
Smoothness of legs /shank/	0	0	0	0	0	0	0	0	14	146	0	0.0316
Head shape	0	0	0	0	0	0	0	0	0	0	160	0.0152
Midland agro-ecology												
Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Plumage color	106	0	22	0	0	3	0	0	0	0	0	0.1510
Comb type	0	96	0	2	25	0	8	0	0	0	0	0.1392
Egg laid/clutch	22	13	96	0	0	0	0	0	0	0	0	0.1445
Body weight /growth	3	22	10	96	0	0	0	0	0	0	0	0.1299
Reproduction/hatching	0	0	3	30	98	0	0	0	0	0	0	0.1114
mothering ability	0	0	0	0	0	128	0	0	3	0	0	0.0908
Adaptation	0	0	0	3	8	0	98	0	0	22	0	0.0718
Length of legs	0	0	0	0	0	0	3	128	0	0	0	0.0616
Shank color	0	0	0	0	0	0	22	3	106	0	0	0.0514
Smoothness of legs /shank/	0	0	0	0	0	0	0	0	22	109	0	0.0332
Head shape	0	0	0	0	0	0	0	0	0	0	131	0.0153

* R1, R2, R3---R11=Rank 1, 2, 3, 4----11 respectively.

Index=sum of (11 for Rank1 +10 for Rank2 +…+1for Rank 11) given for each trait divided by the sum of (11for Rank1 +10 for Rank2 +…+1for Rank 11) for all traits under consideration.

Table 32 (Continued)

Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Highland agro-ecology												
Plumage color	84	0	5	0	0	5	0	0	0	0	0	0.1609
Comb type	0	68	0	12	10	0	4	0	0	0	0	0.1395
Egg laid/clutch	5	21	68	0	0	0	0	0	0	0	0	0.1412
Body weight /growth	5	5	16	68	0	0	0	0	0	0	0	0.1277
Reproduction/hatching	0	0	5	9	80	0	0	0	0	0	0	0.1082
mothering ability	0	0	0	0	0	84	5	0	5	0	0	0.0876
Adaptation	0	0	0	5	4	5	80	0	0	0	0	0.0818
Length of legs	0	0	0	0	0	0	0	94	0	0	0	0.0606
Shank color	0	0	0	0	0	0	5	0	89	0	0	0.0470
Smoothness of legs /shank/	0	0	0	0	0	0	0	0	0	84	10	0.0287
Head shape	0	0	0	0	0	0	0	0	0	10	84	0.0167
Western zone of Tigray												
Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Index
Plumage color	327	0	37	0	0	21	0	0	0	0	0	0.1470
Comb type	0	259	0	51	58	0	13	0	0	4	0	0.1260
Egg laid/clutch	37	89	259	0	0	3	0	0	0	0	0	0.1321
Body weight /growth	21	37	68	259	0	0	0	0	0	0	0	0.1190
Reproduction/hatching	0	0	21	54	310	0	0	0	0	0	0	0.1011
mothering ability	0	0	0	0	5	344	18	0	8	10	0	0.0809
Adaptation	0	0	0	21	13	19	310	0	0	22	0	0.0713
Length of legs	0	0	0	0	0	0	7	377	1	0	0	0.0560
Shank color	0	0	0	0	0	0	37	8	340	0	0	0.0448
Smoothness of legs /shank/	0	0	0	0	0	0	0	0	36	339	10	0.0288
Head shape	0	0	0	0	0	0	0	0	0	10	375	0.0143

* R1, R2, R3---R11=Rank 1, 2, 3, 4----11 respectively.

Index=sum of (11 for Rank1 +10 for Rank2 +…+1for Rank 11) given for each trait divided by the sum of (11for Rank1 +10 for Rank2 +…+1for Rank 11) for all traits under consideration.

Table 33: Ranking of trait of local chickens to be improved through breeding in three agro-ecological zones of Western Tigray

Lowland agro-ecology											
Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Egg laid /clutch	160	0	0	0	0	0	0	0	0	0	0.1818
Body weight /growth	0	132	28	0	0	0	0	0	0	0	0.1605
Adaptation	0	0	132	28	0	0	0	0	0	0	0.1423
Reproduction/hatching	0	28	0	132	0	0	0	0	0	0	0.1336
Plumage color	0	0	0	0	132	28	0	0	0	0	0.1059
mothering ability	0	0	0	0	28	132	0	0	0	0	0.0941
Comb type	0	0	0	0	0	0	132	0	0	28	0.0632
Smoothness of legs /shank/	0	0	0	0	0	0	28	132	0	0	0.0577
Length of legs	0	0	0	0	0	0	0	28	132	0	0.0395
Shank color	0	0	0	0	0	0	0	0	28	132	0.0214
Midland agro-ecology											
Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Egg laid /clutch	131	0	0	0	0	0	0	0	0	0	0.1818
Body weight /growth	0	107	24	0	0	0	0	0	0	0	0.1603
Adaptation	0	0	107	24	0	0	0	0	0	0	0.1421
Reproduction/hatching	0	24	0	107	0	0	0	0	0	0	0.1339
Plumage color	0	0	0	0	107	24	0	0	0	0	0.1058
mothering ability	0	0	0	0	24	107	0	0	0	0	0.0942
Comb type	0	0	0	0	0	0	107	0	0	24	0.0627
Smoothness of legs /shank/	0	0	0	0	0	0	24	107	0	0	0.0579
Length of legs	0	0	0	0	0	0	0	24	107	0	0.0397
Shank color	0	0	0	0	0	0	0	0	24	107	0.0215

* R1, R2, R3---R10=Rank 1, 2, 3, 4----10 respectively.

Index=sum of (10 for Rank1 +9 for Rank2 +…+1for Rank 10) given for each trait divided by the sum of (10 for Rank1 +9 for Rank2 +…+1for Rank 10) for all traits under consideration.

Table 33 (continued)

Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Highland agro-ecology											
Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Egg laid /clutch	94	0	0	0	0	0	0	0	0	0	0.8118
Body weight /growth	0	75	19	0	0	0	0	0	0	0	0.1600
Adaptation	0	0	75	19	0	0	0	0	0	0	0.1418
Reproduction/hatching	0	19	0	75	0	0	0	0	0	0	0.1346
Plumage color	0	0	0	0	75	19	0	0	0	0	0.1054
mothering ability	0	0	0	0	19	75	0	0	0	0	0.0946
Comb type	0	0	0	0	0	0	75	0	0	19	0.0617
Smoothness of legs /shank/	0	0	0	0	0	0	19	75	0	0	0.0582
Length of legs	0	0	0	0	0	0	0	19	75	0	0.0400
Shank color	0	0	0	0	0	0	0	0	19	75	0.0219
Western zone of Tigray											
Traits	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Egg laid /clutch	385	0	0	0	0	0	0	0	0	0	0.1818
Body weight /growth	0	314	71	0	0	0	0	0	0	0	0.1603
Adaptation	0	0	314	71	0	0	0	0	0	0	0.1421
Reproduction/hatching	0	71	0	314	0	0	0	0	0	0	0.1340
Plumage color	0	0	0	0	314	71	0	0	0	0	0.1057
mothering ability	0	0	0	0	71	314	0	0	0	0	0.0943
Comb type	0	0	0	0	0	0	314	0	0	71	0.0.0627
Smoothness of legs /shank/	0	0	0	0	0	0	71	314	0	0	0.0579
Length of legs	0	0	0	0	0	0	0	71	314	0	0.0397
Shank color	0	0	0	0	0	0	0	0	71	314	0.0215

* R1, R2, R3---R10=Rank 1, 2, 3, 4----10 respectively.

Index=sum of (10 for Rank1 +9 for Rank2 +…+1for Rank 10) given for each trait divided by the sum of (10 for Rank1 +9 for Rank2 +…+1for Rank 10) for all traits under consideration.

4.3. Indigenous Chicken Composition Based on Function in the Flock

The analysis of local chicken composition based on function during the monitoring phase of the study revealed that the overall mean of breeding males, breeding females, replacement young males, replacement young females, females for egg production, females for meat production, males for meat production were 1.53±0.07, 4.97±0.20, 2.33±0.13, 5.73±0.27, 5.15±0.24, 5.68±0.31 and 2.12±0.12, respectively in the study area (Table 34). The mean number of breeding males in the lowland agro-ecology (1.92±0.13) was significantly higher than from both midland (1.40±0.35) and highland (1.28±0.13). The average number of young replacement males and females for egg production in the lowland ecotype (2.60±0.22 and 6.00±0.42, respectively) were significantly higher than from highland ecotypes (1.80±0.22 and 4.48±0.42, respectively) but not from midland chicken ecotypes. However, the mean number of female breeding chickens, young replacement females, females and males for meat production were not significantly different among the three altitudes.

The overall average number of hens in laying eggs, sitting on eggs, looking after chicks and idle hens in the previous nesting (before the start of the monitoring phase of the survey) were 1.53±0.11 (28.35±2.10%),1.17±0.07 (25.04±1.80%), 0.99±0.07 (19.91±0.07%) and 1.28±0.09 (26.70±1.62%), respectively in the study area. Higher mean number of hens in laying eggs in lowland agro-ecology (2.44±0.19 or 41.50±3.64%) during the previous nesting was significantly greater than from both midland (1.24±0.19 or 25.94±3.64%) and highland (0.92±0.19 or 17.6±3.64%). Likewise, the average number of hens sitting on eggs during the previous nesting in the lowland chicken ecotypes (1.48±0.12 or 29.04±3.12%) was significantly superior to highland (0.92±0.12 or 22.40±3.12%) but not different from midland ecotypes (1.12±0.12 or 23.67±3.12%). Nonetheless, the mean number of hens looking after chicks during the previous sitting was not significantly different across the three agro-ecological zones. The mean number of idle hens during the previous nesting in the lowland ecotypes was significantly lower than both midland and highland ecotypes but no significant variation was observed between midland and highland chicken ecotypes. In the same way, the overall mean number of hens in laying eggs, sitting on eggs, looking after chicks and idle hens during current nesting (after the start of the monitoring phase of the survey) was

2.08±0.12 (40.14±1.84%), 0.80±0.02 (15.89±1.55%), 1.01±0.07 (23.31±2.08%) and 1.07±0.10 (23.34±13.6%), respectively in the study area. The mean number of hens sitting on eggs during the current nesting in the lowland was significantly higher than both midland and highland but no significant variation was observed between midland and highland agro-ecologies. Moreover, the mean number of hens in laying eggs in the lowland ecotypes was significantly superior to highland ecotype but not midland ecotypes.

However, the average number of hens looking after and idle hens were not significantly different across the three agro-ecological zones of the study area. Likewise, Bogale (2008) also reported somewhat comparable results which stated that 28.93%, 22.22%, 34.26% and 17, 59% of Fogera hens were found to be laying eggs, sitting on eggs, looking after chicks and idle hens, respectively.

The result of the monitoring phase of the survey also indicated that the overall mean weight of day old, one week, one month, two month and three month old of local chicken raised under extensive management of the study area were found to be 37.96±0.18 gram, 40.19±0.19 gram, 144.13±0.53 gram, 303.04±1.23 gram and 517.25±1.25 gram, respectively (Table 35). The average weight of day old, one week, one month and three month of the local chickens were significantly different among the three agro-ecological zones of the zone. Significantly superior average weight of day old and one week chickens were obtained from highland ecotypes followed by midland while the least was recorded from lowland ecotypes. This may be due to extreme temperature difference among the three altitudes. However, significantly highest mean weight of one month and two month old chickens were attained from lowland chicken ecotypes followed by midland ecotypes whereas the least was obtained from highland chicken ecotypes. Similarly, the highest mean weight of three month old chickens was recorded from midland ecotypes followed by lowland ecotypes while least was obtained from highland ecotypes. This might be due to management level differences in favor of lowland and midland.

This result was higher than 28.76 ±2.15 gm ranging from 22-43 gm and 27.3 gm reported by Bogale (2008) and Halima (2007) in Fogera district and North West Ethiopia, respectively.

Moreover, Tadelle & Ogle (2001) also reported lower figures on average weight of day old chicks (28±4 gram ranging from 18-36 gram) and 8 weeks old (185±13 gram ranging from 152-213 gram) in the Central highlands of Ethiopia.

Table 34: Local chicken ecotypes composition by function from monitoring (Lsmeans ± SE) in three agro-ecological zones of Western Tigray.

Traits	Agro-ecological zones				
Breeding chicken	Lowland	Midland	Highland	Overall	CV
Males	1.92± 0.13[a]	1.40 ± 0.13 [b]	1.28 ± 0.13[b]	1.53±0.07	41.30
Females	5.64 ± 0.35[a]	4.80 ±0.35 [a]	4.48± 0.35 [a]	4.97±0.20	34.99
Replacement chicken					
Young males(no)	2.60 ±0.22[a]	2.60 ±0.22 [a]	1.80± 0.22[b]	2.33±0.13	47.92
Young females(no)	5.12 ±0.47[a]	6.44 ±0.47 [a]	5.64±0.47 [a]	5.73±0.27	40.83
Females for egg prod	6.00±0.42[a]	4.96±0.42[ab]	4.48±0.42[b]	5.15±0.24	41.04
Females for meat prod	5.80 ±0.54 [a]	5.76 ±0.54 [a]	5.480 ±0.54 [a]	5.68±0.31	47.17
Males for meat prod	2.20 ±0.21 [a]	2.32 ±0.21 [a]	1.84 ±0.21 [a]	2.12±0.12	49.97
Previous nesting					
Hen in lay	2.44 ±0.19 [a]	1.24 ±0.19[b]	0.92 ±0.19[b]	1.53±0.11	60.79
Hen in lay (%)	41.50±3.64 [a]	25.94 ±3.64[b]	17.61 ±3.64[b]	28.35±2.10	64.23
Hens sitting on eggs	1.48 ± 0.12 [a]	1.12 ±0.12[ab]	0.92 ±0.12[b]	1.17±0.07	49.94
Hens sitting eggs (%)	29.04±3.12 [a]	23.67±3.12[a]	22.40±3.12[a]	25.04±1.80	62.21
Hens looking after chick	1.24 ±0.12 [a]	0.88± 0.12 [a]	0.84± 0.12[a]	0.99±0.07	61.56
Hens looking after chick (%)	21.22± 2.65 [a]	17.62 ±.65 [a]	20.90 ±2.65 [a]	19.91±1.53	66.43
Idle hens	0.48 ±0.16 [b]	1.56 ±0.16 [a]	1.80 ±0.16 [a]	1.28±0.09	62.72
Idle hens (%)	8.25±2.80[b]	32.77±2.80 [a]	39.08±2.80 [a]	26.70±1.62	52.44
Current nesting					
Hen in lay	2.52 ±0.21[a]	1.92 ±0.21[ab]	1.80± 0.21[b]	2.08±0.12	49.42
Hen in lay (%)	42.12 ±3.18 [a]	39.12 ±3.18 [a]	39.18±3.18 [a]	40.14±1.84	39.62
Hens sitting on eggs	1.16 ±0.12 [a]	0.64 ±0.12[b]	0.60 ±0.12 [b]	0.80±0.07	76.72
Hens sitting eggs (%)	20.31 ±2.69 [a]	12.32±2.69 [a]	15.03±2.69 [a]	15.89±1.55	84.66
Hen looking after chicks	1.12± 0.12 [a]	1.08±0.12 [a]	0.84 ±0.12 [a]	1.01±0.07	56.78
Hen looking after chick	21.98±3.60 [a]	27.02 ±3.60 [a]	20.91±3.60 [a]	23.31±2.08	77.17
Idle hens	0.84±0.17 [a]	1.12 ±0.17 [a]	1.24± 0.170 [a]	1.07±0.10	80.10
Idle hens (%)	17.14 ±2.72 [a]	25.31 ±2.72 [a]	21.58 ±2.72 [a]	23.34±13.6	63.69

LS-means with different superscripts in the same row are significantly different ($p>0.05$)

Table 35: Least squares mean for early measured weights of the local chicken ecotypes in the three agro-ecological zones of western Tigray (Lsmeans ± SE) from monitoring

Chickens wt (gm) at the age of	Agro-ecological zones				
	High (n=42)	Mid (n=65)	Low (n=42)	Overall (N=149)	CV
Day old	41.05± 0.33^{a}	38.57± 0.27^{b}	34.28 ±0.3^{c}	37.96±0.18	5.63
One week	43.13 ±0.35^{a}	39.99 ± 0.28^{b}	37.45 ±0.3^{c}	40.19±0.19	5.71
One month	135.44± 0.98^{c}	144.94±0.78^{b}	152.02±0.98^{a}	144.13±0.53	4.39
Two month	294.07±2.28^{b}	305.48±1.83^{a}	309.58±2.28^{a}	303.04±1.23	4.86
Three month	465.97±4.62^{c}	572.93±3.71^{a}	512.85±4.62^{b}	517.25±2.50	5.69

LS-means with the different letter in the same row are significantly different ($p<0.05$).

4. 4. Reproductive and Productive Traits of Local Chicken Ecotypes

Both reproductive and productive performances of local chicken ecotypes in each agro-ecological zone of the study area were almost similar from the data collected through the survey and the monitoring phase of the study for the traits recorded in both phases of the study. This implies how livestock owners (farmers) are good enough in remembering performance of their individual animals without data recording. Recalling data can be used for evaluation and selection of best individual animals under scavenging production system where performance data recording is scanty.

4.4.1. Reproductive Performance of Local Chickens

The result of the survey revealed that the overall mean age of sexual maturity was 7.19 ±0.04 and 5.71±0.03 months for females and males respectively in the study area (Table 36). There were highly significant differences in age at sexual maturity of female and male chickens among the three agro-ecological zones of the study area. Significantly highest age at sexual maturity of both male and female chickens was obtained from highland (5.91±0.05 and 7.72±0.07 months) followed by midland (5.73±0.05 and 7.25±0.06 months) while the least age at sexual maturity of both sexes were attained from lowland agro-ecology (5.48±0.05 and 6.61±0.06 months). This result was somewhat comparable with the findings of Meseret (2010) who reported that the male and female local chicken of Gomma wereda of Jimma

Zone attained sexual maturity at 6.47±0.91 and 6.33±0.80 months, respectively. In Sudan, the age at sexual maturity of two Sudanese native chicken ecotypes of Dwarf (Betwil) and bare neck ecotypes was 163.9 days and 184.9 days ,respectively(Yousif & Eltayeb, 2011). Sonaiya & Swan (2004) also reported similar findings that indigenous village chicken, in Ethiopia attains sexual maturity at an average of 7 months. However, this result was higher than the findings of Addisu *et al*. (2013) and Bogale (2008) who reported the age of sexual maturity of indigenous male and female of (24.25±0.04 & 23.84±0.05 weeks) and (23.48±0.01 &23.6±0.11 weeks), respectively in north Wollo zone and Fogera district of Amhara regional state of Ethiopia. Solomon *et al*. (2013) also reported lower values on the average age sexual maturity/age at first mating/ of indigenous pullets and cockerels in Metekel Zone of North West Ethiopia were 5.2±1.16 and 5.44±1.3 months respectively.

The overall mean of slaughter (marketable) age was 4.66±0.03 and 4.50±0.03 months for males and female respectively in the study area (Table 36). There was significant variation in slaughter or marketable age of female chickens among the three altitudes. Significantly maximum slaughter or marketable age was recorded from highland chicken ecotypes (4.86±0.05 months) followed by midland (4.68±0.05 months) while the least and most desirable slaughter or marketable age for poultry meat industry (broiler) was obtained from lowland chicken ecotypes (4.44±0.05month). Similarly, significantly lesser slaughter age of male chickens was obtained from lowland agro-ecology (4.32±0.05 months) than both highland (4.60±0.05months) and midland (4.57±0.05 months) but no significant variation in slaughter age of male was observed between midland and highland agro-ecological zones. This result was lower than 8.62±1.92 months mean age at slaughter weight of 1.5 kg of male chickens of Gomma wereda of Jimma zone under scavenging conditions (Meseret, 2010).

The overall mean of age at first egg laying for female local chickens in the study area was 7.19±0.04 months. There was highly significant difference in means of age at age first egg laying ($p<0.05$). The significantly highest mean age at first egg laying of female chickens was obtained from highland chicken ecotypes (7.72±0.079 months) followed by midland (7.25±0.06 months) while the lowest age at first egg laying was recorded in the lowland chicken ecotypes (6.61±0.06 months). This result was in line with the report of Matiwos *et al.*

(2013) in which the mean age at first egg laying of indigenous pullets in the Nole Kabba wereda of Western Wollega was 7.02±0.22 months. This result was also comparable with the findings of Mekonnen (2007) who reported that the mean age at first egg laying of young indigenous pullets in three districts of SNNPRs was 28.28 weeks. Tadelle *et al*. (1996) also reported similar figures in which the mean age at first egg lying of indigenous young pullets in the central high lands of Ethiopia was ranging from 24.4 to 32.64 weeks. Moreover, Tadelle & Ogle (2001) also reported comparable result on age at first egg laying of indigenous female chickens (195±28 days ranging from 183-215 days) in the central highland of Ethiopia. However, this result was longer than the average age of age at first egg laying of indigenous young pullets in North West Ethiopia (Halima, 2007), North Wollo zone of Amhara region (Addisu *et al*., 2013) and in different parts of Ethiopia (Tadelle,*et al*., 2003b) were 20 weeks, 25.97±0.04 weeks and 27.2 weeks respectively. In Kenya, Okeno *et al*. (2010) also reported lower figures on the average age at sexual maturity of Kenyan indigenous chickens under scavenging conditions was 6.73±0.3 months ranging from 6-11. Worku *et al*. (2012) also reported slightly lower values of average age at first egg laying of local chickens in West Amhara region of Ethiopia was 6.6±1.60 months.

The result also indicated that the overall mean age of reproductive life of matured male and female local chicken ecotypes was 2.85±0.04 years and 3.31±0.05 years respectively in the study area (Table 36). The mean age of reproductive life of matured male local chicken did not differ among the three agro-ecologies. However, slightly higher mean age of reproductive life of males was obtained from highland ecotypes (2.89±0.07 years) followed by lowland (2.88±0.07 years) and midland (2.78±0.07 years). However, significantly higher mean age of reproductive life of matured local female chickens was obtained from highland chicken ecotypes (3.61±0.09 years) than midland chicken ecotypes (2.91±0.08 years) but not different from lowland chicken ecotypes (3.43±0.08 years). This result was slightly lower than from the findings of Solomon *et al*. (2013) in which the average reproductive life span of male and female indigenous chickens in Metekel Zone of North West Ethiopia were 3.79±0.15 and 3.56±0.14 years respectively.

Pertaining to number of clutches per year per hen, the result of the survey indicated that the overall mean of number of clutches per hen per year of local chicken ecotypes was 4.42±0.04 in the study zone (Table 36). Significantly higher mean number of clutches per year per hen of local chicken ecotypes was obtained from midland ecotypes (4.57±0.06) than both highland (4.35±0.07) and lowland (4.34±0.08) ecotypes but no significant variation was observed between highland and lowland chicken ecotypes. This result was comparable with the findings of Solomon *et al*. (2013) in which the average number of clutches per hen per of indigenous chickens in Metekel Zone of North West Ethiopia was 4.29±0.17.

However, it was higher than the reports of Meseret (2010), Mekonnen (2007) and Addisu *et al*. (2013) in which the mean clutch number of indigenous chickens in Gomma wereda , three districts of SNNPRs and North Wollo zone of Amhara regional state of Ethiopia was 3.43/year, 3.8/year and 3.62±0.02/year respectively. But it was comparable with the findings of Yousif & Eltayeb (2011) in which the average number of clutches of Dwarf and Bare Neck indigenous chicken ecotypes of Sudan under scavenging conditions was 5 and 4 respectively. In Kenya, Okeno *et al*. (2010) also reported that the average number of clutches per hen per year of Kenyan indigenous chickens under scavenging conditions was 3.1±0.7 ranging 2-4. Worku *et al*. (2012) also reported lower values of average number of clutches per hen per year of local chickens in West Amhara region of Ethiopia was 3.24±0.60.

The overall mean number incubated eggs, hatched chicks and wasted eggs per clutch of local chicken ecotypes were 10.9±0.12, 8.17±0.11 and 2.73±0.06 respectively from the survey (Table 36). Similar results had been obtained on these traits during the monitoring phase of the study in which the overall mean of incubated eggs, hatched chicks and wasted eggs per clutch were 10.42±0.20, 8.14±0.18 and 2.24±0.10 respectively (Table 40). The result from both phases revealed that the mean number of incubated eggs in the midland chicken ecotype from the survey (11.22±0.19) and monitoring (11.87±0.35) was significantly higher than lowland chicken ecotypes in both survey (10.40±0.18) and monitoring (9.57±0.35) and highland ecotypes from monitoring (9.83±0.35) but no significant variation was observed between midland (11.22±0.19) and highland (11.07±0.21) chicken ecotypes from the survey and there was no significant variation between lowland (9.57±0.35) and highland (9.83±0.35) from the monitoring phase of the study.

In the same way, the number of hatched chicks per clutch of lowland chicken ecotypes from both recalling data during the survey (6.40±0.18) and monitoring (5.80±0.31) was significantly lower than both midland ecotypes from survey (8.44±0.18) and monitoring (9.93±0.31) and highland chicken ecotypes from survey (9.68±0.20) and monitoring (8.70±0.31). Significantly higher number of hatched chicks per clutch was obtained from highland ecotypes (9.68±0.20) than midland (8.44±0.18) from the recalling data of the survey but significantly superior figure was obtained from midland to highland from the monitored data. There was highly significant difference in number of wasted eggs per clutch of local chickens among the agro-ecological zones. Significantly highest number of wasted eggs per clutch from both recalling data (4.00±0.10) and monitored data (3.70±0.18) was obtained from lowland chicken ecotypes while the least figure from both recalling data (1.39±0.12) and monitored data (1.10±0.18) was attained from highland chicken ecotypes. The similarity between the recall and monitoring data indicates the fact that the farmers recall data could be useful in evaluating of the local chicken performance and management for genetic improvement provided that the sampling procedure is acceptable with appropriate facilitation.

This result showed an agreement with the report of Addisu *et al*. (2013) in which the mean number of incubated eggs and hatched chicks per clutch of indigenous chickens in North Wollo Zone of Amhara Regional state was 11.36±0.09 and 9.60±0.10 respectively. Worku *et al*. (2012) also reported somewhat similar values of average number of eggs incubated and eggs hatched per clutch per hen of local chickens in West Amhara region of Ethiopia were 12.8±2.30 and 10.00±2.30 respectively. Likewise, Wondu *et al*. (2013) reported closer values on the average number of incubated eggs and hatched eggs per clutch per hen of local chickens in the North Gondar Amhara regional state of Amhara was 10.95±0.22 (7-15) and 9.49±0.20 (7-14) respectively.

On the other hand, this result was lower than the average number of eggs set/clutch (13±2.2 ranging from 7-19) and number of hatched eggs/clutch (11±2.3 ranging from 4-16) of the indigenous chickens in Central highlands of Ethiopia (Tadelle & Ogle, 2001). In Kenya, Okeno *et al*. (2010) also reported similar findings on the average incubated eggs and hatched eggs per set of Kenyan indigenous chickens under scavenging conditions were 12.84±0.4 (ranging 7-15) and 10.73±1.8 (ranging 5-15) respectively.

The overall mean weaning age of chicken ecotypes was 2.55±0.53 months in the study area. Significantly earlier mean weaning age (2.33±0.04 months) was obtained from lowland chicken ecotypes than both highland (2.67±0.05 months) and midland (2.66±0.04) chicken ecotypes but no significant variation was observed between midland and highland chicken ecotypes. This was in line with the findings of Meseret (2010) in which the average weaning age of indigenous chickens of Gomma Wereda of Jimma zone was 2.61±0.45 months. This result also agreed with the findings of Solomon *et al*. (2013) showed that the average weaning age of local chickens in Metekel Zone of North West Ethiopia was 8.51±0.40 weeks.

The overall mean of the hatchability (%) and number of weaned chicks per clutch and survival rate to weaning age (%) of the local chicken ecotypes were 74.37±0.57, 5.92±0.08 and 73.06±0.51 respectively from recalling data and 77.58±0.89, 3.60±0.17 and 44.56±1.17 respectively from monitored data in the study area.

There was significant difference in hatchability of eggs across the three chicken ecotypes. Significantly least hatchability of eggs was obtained from lowland chicken ecotypes in both recalling data (61.34±0.92) and monitored data (60.43±1.54) while the highest was attained from highland chicken ecotypes in both recalling data (87.29±1.06) and monitored data (88.67±1.54) though the hatchability of eggs from the monitored data was not significantly different between highland and midland chicken ecotypes. In similar context, significantly least number of weaned chicks per clutch was obtained from lowland chicken ecotypes in both recalling data (4.76±0.14) and monitored data (2.70±0.20) whereas the highest number of weaned chicks per clutch was recorded from highland chickens in the recalling data (6.72±0.16) and from midland chicken ecotypes in the monitored data (4.27±0.20) though there was no significant variation between midland and highland chicken ecotypes in both recalling and monitored data. However, least survival rate to weaning age was obtained from highland chicken ecotypes in the recalling data (69.83±0.95) while highest survival rate was attained from midland chicken ecotypes (75.01±0.86) even if no significant variation was observed between midland and lowland chicken ecotypes from the recalling data. This result was somewhat similar with the findings of Okeno *et al*. (2010) in which the average number of weaned chicks or survive to weaning was 6.04±1.4 (2 - 8).

The result of the survey also revealed that the overall mean numbers of chicks survive to adulthood, survival rate to adulthood, incubation frequency per year and numbers of days per clutch were 4.13±0.08, 50.45±0.64, 2.94±0.03 and 22.19±0.16 days respectively in the study area. Significantly lower number of chicks survive to adult hood was obtained from lowland chicken ecotypes (3.30±1.03) while the higher was recorded from highland chicken ecotypes (4.65±0.15) though no significant variation was observed between midland and highland chicken ecotypes. Worku *et al*. (2012) also reported slightly greater values of average number of chicks survive to adulthood per clutch per hen and survivability to adulthood of local chickens in West Amhara region of Ethiopia were 5.50±1.70 and 58.25±2.30 respectively. The mean number of incubation frequency per year did not differ among the three chicken ecotypes. This result was comparable with the reports of Wondu e*t al*. (2013) in which the mean number of times the hen hatches eggs/year, of local chickens in North Gondar Amhara regional state was 2.59±0.05 (2-3). However this result was higher than the number of times the indigenous hen hatches per year of 1.85±0.51 reported by Meseret (2010) in Gomma Wereda. The mean number of days per clutch in the lowland chicken ecotypes was significantly lower than both midland (23.01±0.18) and highland (22.96±0.30) chicken ecotypes but no significant variation was observed between midland and highland chicken ecotypes.

This result was slightly lower than the report of Meseret (2010) in which the average number of days per clutch of indigenous chickens of Gomma Wereda of Jimma zone was 25.29±4.39 days. Similarly, Yousif & Eltayeb (2011) also reported lower figures on the average clutch length of Dwarf and Bare Neck indigenous chickens of Sudan under scavenging management conditions was 14.44 days and 20.04 days respectively.

The result of the monitoring phase of the study indicated that the overall mean approximate age of local chicken layers, number of chicks survive to 30 days, survival rate to 30 days, number of survive chicks to 60 days and survival rate to 60 days of local chicken ecotypes was 2.21±0.10 years, 5.06±0.14, 63.24±1.24, 4.10±0.13 and 51.02±1.22 respectively in the study area. There was no significant variation in the mean of approximate age of local layers. There was significant difference in the mean number of survive chicks to 30 days across the three agro-ecological zones in which the highest mean of survive chicks to 30 days was obtained from midland chicken ecotypes (6.20±0.24) while the least was obtained from lowland chicken ecotypes (3.97±0.24). Similarly, the least mean number of survive chicks to 60 days was obtained from lowland chicken ecotypes (3.17±0.22) whereas highest mean number of survive chicks to 60 days was recorded from midland chicken ecotypes 4.83±0.22) even if no significant variation was observed between midland and highland chicken ecotypes.

The result of the monitoring phase of the study indicated that the overall mean number of survive chicks to 90 days and the survive rate to 90 days (%) was 3.11±0.10 and 39.84±1.10 respectively in the study area. Significantly lower number of survive chicks to the 90 days was obtained from lowland chicken ecotypes (2.70±0.16) than midland chicken ecotypes (3.73±0.16) but not significantly different from highland chicken ecotypes (2.90±0.16). In the reverse context, significantly higher survival rate to the 90 days (%) was obtained from lowland chicken ecotypes (47.78±1.91) than both highland (33.54±1.91) and midland (38.18±1.91) chicken ecotypes but no significant variation was observed between highland and midland chicken ecotypes.

This result slightly agreed with the findings of Halima (2007), Matiwos *et al*. (2013) and Tadelle & Ogle (2001) in which the average hatchability of eggs of indigenous chickens under scavenging management condition was 60.7% to 82.1%, 82.74 % and 81±11% (ranging 44-100) in North Western of Ethiopia, Nole Kabba wereda of Western Wollega and in Central highlands of Ethiopia respectively. On the other hand, this result was higher than from the findings of Meseret (2010) and Yousif & Eltayeb (2011) who reported that the average hatchability of indigenous chickens in Gomma wereda (22%) and the mean hatchability of

Dwarf (65.6%) and Bare Neck (59.09%) indigenous chickens of Sudan under scavenging conditions respectively. In Kenya, Okeno *et al*. (2010) also reported a similar finding on the hatchability of Kenyan indigenous chickens under scavenging conditions was 83.6%. Worku *et al*. (2012) also reported slightly similar figures on the egg hatchability of local chickens in West Amhara region of Ethiopia was 79.1±17.0 %. However, this result was lower than the findings of Solomon *et al*. (2013), Wondu *et al*. (2013), Nebiyu *et al*. (2013) in which the average egg hatchability of local chickens in Metekel Zone of North West Ethiopia, North Gondar Amhara regional state and Halaba wereda of southern Ethiopia were 84.74%,87.29±0 .999 and 83.72% respectively.

4.4.2. Productive performance of local chicken ecotypes.

The results of both recalling data and monitored data revealed that the average number of eggs laid per clutch of indigenous chicken ecotypes in the study area was 12.01±0.12 and 14.53±0.35 respectively (Table 34 and 35). Significantly lower average number of eggs laid per clutch was obtained from lowland chicken ecotypes in both recalling data (11.41±41) and monitored data (12.90±0.61) than highland (12.56±0.23) but not significantly different with midland ecotypes (12.07±0.21) from the recalling data, and the lowland chicken ecotypes was not significantly different highland ecotypes (13.0±0.61) but significantly lower than midland chicken ecotypes (17.73±0.61) from the monitored data. This result was in line with the reports of Meseret (2010), Addisu *et al*. (2013), Wondu *et al*. (2013) and CSA (2003) in which the mean egg number laid per clutch per hen of local chickens in Gomma wereda, North Wollo Zone North Gondar Amhara region and Ethiopia were12.92, 12.64±0.1, 11.53±0.21 (8-15) and 12(national average of egg yield/hen/clutch) respectively. However, it was lower than from the reports of Solomon *et al*. (2013), Bogale (2008), Mekonnen (2007), Worku *et al*. (2012) and Tadelle (2003) in which the average number of eggs laid per clutch of local chickens in Metekel Zone of North West Ethiopia, Fogera district, Southern Ethiopia (Dale,Wonsho,Loka Abaya wereda), West Amhara region of Ethiopia and five agro-ecological zones of Ethiopia were 13.56±0.26 eggs,16.6eggs,14.9 eggs, 14.1±3.25 and 17.7 eggs, respectively. In Kenya, Okeno *et al*. (2010) also reported higher values of average number of eggs laid per clutch of the Kenyan indigenous chickens under scavenging conditions was 15.37±0.6 (7- 18).

The result of the survey (recalling data) indicated that the mean annual egg production per hen in the study area was 52.68±0.57 (Table 36). Significantly lower mean annual egg yield per hen was obtained from lowland chicken ecotypes (48.98±0.92) than both highland (54.20±1.07) and midland chicken ecotypes (54.87±0.97) but no significant variation was observed between highland and lowland chicken ecotypes. This was comparable with the mean annual egg yield per hen of indigenous chickens of Fogera district (53eggs) and Dale district (55 eggs) (Fisseha *et al*., 2010) and Loka A district (54.9±3.27 eggs) and Dale district (51.44±1.40 eggs) (Mekonnen, 2007). However, this result was higher than the reports of Meseret (2010), Halima (2007), Ayalew & Adane (2013) and Addisu *et al*. (2013) in which the mean annual egg yield per hen of indigenous chickens in Gomma wereda of Jimma zone, North West Ethiopia, Chagni town in Awi administrative Zone Amhara and North Wollo zone of Amhara was 43.8 eggs, 18-57 eggs, 27-45 eggs and 49.51±0.38 eggs respectively. On the other hand, this result was lower than the mean annual egg yield of indigenous chickens in Bure district (60 eggs) (Fisseha *et al*., 2010), Wonsho district (62.95±2.29 eggs) (Mekonnen, 2007) and Enebsie Sar Midir Wereda of Eastern Gojjam (65 eggs) (Yitbarek & Zewudu, 2013). Worku *et al*. (2012) also reported lower values of mean annual egg production per hen of local chickens in West Amhara region of Ethiopia was 45.7±9.80 eggs. Solomon *et al*. (2013) also reported a greater value on the average annual egg production per year per hen of local chickens in Metekel Zone of North West Ethiopia was 59.51±2.66 eggs.

The result of the survey also indicated that clutch number had significant effect on average egg production per hen per clutch (Table 38). The overall average egg production per clutch of local chicken ecotypes in the first clutch, second, third, fourth, fifth and sixth were 11.32±0.14, 12.21±0.13, 14.42±0.3, 11.33±0.15, 9.25±0.12 and 7.58±0.80 respectively in the study area. Average egg yield per clutch per hen showed a trend of increasing from first clutch up to third clutch in which the maximum average egg yield per clutch was attained and then started to decrease from Clutch four. This result was in line with the findings of Addisu *et al.* (2013) in which the average egg production per clutch per hen in North Wollo Zone in the first, second, third, fourth and fifth clutch was 10.11±0.15, 12.85±0.17,14.41±0.08, 13.76±0.17 and 11.12±0.20 respectively. Tadelle *et al*. (2003) also reported similar findings on the trend of overall mean egg laying performance of indigenous hens for the first, second and third clutches were 17.0, 20.9 and 24.8 eggs respectively and layers laid 8 eggs more by the third clutch compared to the first clutch.

The probable reason for decline of egg yield after third clutch might be due to hens lay fewer eggs as they get older. Because hens start laying eggs at the age of 22- 32 weeks depending on the breed type, their health status and development, housing and nutrition . Hens reach peak production at about 35 weeks, with a production rate greater than 90% (i.e. 9 eggs in 10 days for a single hen or 9 eggs from 10 birds daily). This period of peak production lasts about 10 weeks, after which their egg production slowly begin to decline. After this peak in production, the rate of lay decreases about 1% to 1.5% per week (FAO, 2009b).

Table 36: Least square means for productive and reproductive traits of local chicken ecotypes in three agro-ecological zones of Western Tigray (Lsmeans ± SE): survey

Traits	Agro-ecological zones				
	Highland	midland	lowland	overall	CV
Age of sexual maturity(month)					
Female	7.72 ±0.07[a]	7.25 ±0.06[b]	6.61 ± 0.06[c]	7.19±0.04	10.13
Male	5.91 ±0.05 [a]	5.73 ±0.05[b]	5.48 ±0.05[c]	5.71±0.03	9.90
Slaughter/marketable age(month)					
Female	4.86 ±0.05[a]	4.68 ±0.05[b]	4.44 ±0.05[c]	4.66±0.03	11.92
male	4.60 ± 0.05[a]	4.57 ±0.05[a]	4.32 ±0.05[b]	4.50±0.03	12.16
Age at first egg laying (months)	7.72 ±0.07[a]	7.25 ±0.06[b]	6.61 ±0.06[c]	7.19±0.04	10.13
Reproductive life (years)					
male	2.89 ±0.08 [a]	2.78 ±0.07[a]	2.88 ±0.07[a]	2.85±0.04	28.40
female	3.61 ±0.09[a]	2.91 ±0.08[b]	3.43 ±0.08[a]	3.31±0.05	28.70
Egg laid/clutch/hen	12.56±0.23[a]	12.07±0.21[ab]	11.41±0.20[b]	12.01±0.12	20.16
No of clutches/year/hen	4.35±0.07[b]	4.57 ±0.06[a]	4.34 ±0.06[b]	4.42±0.04	16.09
Annual egg yield/hen	54.20 ±1.07[a]	54.87 ±0.97[a]	48.98 ±0.92[b]	52.68±0.57	21.22
No of incubated eggs /clutch	11.07 ±0.21[a]	11.22 ±0.19[a]	10.40± 0.18[b]	10.90±0.12	19.71
No of hatched chicks/set	9.68 ±0.20 [a]	8.44 ±0.18 [b]	6.40 ±0.18[c]	8.17±0.11	26.38
No of wasted eggs/clutch	1.39 ±0.12[c]	2.79 ±0.11[b]	4.00 ±0.10[a]	2.73±0.06	43.84
Hatchability (%)	87.29±1.06[a]	74.47 ±0.97[b]	61.34 ±0.92[c]	74.37±0.57	15.17
No of weaned chicks/clutch	6.72 ±0.16[a]	6.27 ±0.14[a]	4.76 ±0.14[b]	5.92±0.08	27.95
Survival rate to weaning age (%)	69.83±0.95[b]	75.01±0.86[a]	74.34 ±0.82[a]	73.06±0.51	13.49
Weaning age(months)	2.67± 0.05[a]	2.66 ±0.04[a]	2.33 ±0.04[b]	2.55±0.03	19.87
No of chicks survive to adulthood	4.65±0.15[a]	4.44 ± 0.14[a]	3.30± 0.13[b]	4.13±0.08	38.76
Survival rate to adulthood (%)	47.62± 1.17[b]	52.49± 1.08[a]	51.26 ±1.03[ab]	50.45±0.64	24.46
Incubation frequency /year	3.01 ±0.06[a]	3.06 ±0.06[a]	2.76 ±0.05[b]	2.94±0.03	21.87
No of days /clutch	22.96 ±0.30[a]	23.01±0.28[a]	20.61 ±0.26[b]	22.19±0.16	14.41

LS-means with the same letter in the same row are not significantly different (p>0.05)

Table 37: Productive and reproductive traits (functional traits) of local chicken ecotypes collected through monitoring in three agro-ecological zones of western Tigray (Lsmeans±SE)

Traits	Agro-ecological zones				
	Lowland	Midland	Highland	Overall	CV
Egg laid/clutch	12.90 ±0.61[b]	17.73± 0.61[a]	13.0 ± 0.61[b]	14.53±0.35	22.93
Eggs incubated(No)	9.57 ±0.35[b]	11.87±0.35[a]	9.83 ±0.35[b]	10.42±0.20	18.43
Hatched chicks(No)	5.80 ±0.31[c]	9.93 ±0.31 [a]	8.70 ±0.31[b]	8.14±0.18	20.94
Hatchability (%)	60.43± 1.54[b]	83.64±1.54[a]	88.67± 1.54[a]	77.58±0.89	10.87
Wasted eggs (No)	3.70 ±0.18 [a]	1.93± 0.18[b]	1.10 ± 0.18[c]	2.24±0.10	43.48
Weaned chicks(No)	2.70 ±0.20 [b]	4.27 ±0.20[a]	3.83±0.20 [a]	3.60±0.12	30.71
Survival rate to weaning (%)	45.84 ±2.03[a]	43.67± 2.03 [a]	44.18±2.03[a]	44.56±1.17	24.93
Approximate age of layer(years)	2.05 ±0.17 [a]	2.35±0.17 [a]	2.24 ±0.17 [a]	2.21±0.10	42.42
Survive chicks to 30 days(No)	3.97 ±0.24[c]	6.20± 0.24[a]	5.00± 0.24[b]	5.06±0.14	25.95
Survival rate to 30 days (%)	68.87±2.13[a]	63.35±2.15[ab]	57.51±2.15[b]	63.24±1.24	18.62
Survive chicks to 60 days(No)	3.17±0.22[b]	4.83± 0.22[a]	4.30 ±0.22 [a]	4.10±0.13	28.96
Survival rate to 60 days (%)	54.38 ±2.10[a]	49.12±2.10 [a]	49.56±2.10 [a]	51.02±1.22	22.59
Survive chicks to 90 days(No)	2.70 ±0.16[b]	3.73 ±0.16[a]	2.90± 0.16[b]	3.11±0.10	29.01
Survival rate to 90 days (%)	47.78± 1.91[a]	38.18±1.91[b]	33.54 ±1.91[b]	39.84±1.10	26.29

LS-means with the same letter in the same row are not significantly different (p>0.05)

Table 38: Egg yield of different clutch numbers of local chicken ecotypes in the three agro-ecological zones of Western Tigray (from survey) (Lsmeans±SE)

Traits	Agro-ecological zones				
	Lowland	Midland	Highland	Overall	CV
Clutch number /year/hen	4.28 ±0.02[c]	4.60±0.03 [a]	4.46 ±0.03[b]	4.44±0.02	15.92
Egg yield at clutch number					
One	10.69 ±0.20[b]	12.01 ± 0.23[a]	11.27± 0.27[ab]	11.32±0.14 [c]	22.95
Two	11.84 ±0.20[a]	12.37 ±0.22 [a]	12.40± 0.26[a]	12.21 ± 0.13[b]	20.4
Three	13.79 ±0.46[a]	14.01 ± 0.51[a]	15.48 ±0.60[a]	14.42± 0.30[a]	40.76
Four	10.22± 0.22[c]	11.32 ±0.25[b]	12.48 ±0.29[a]	11.33± 0.15[c]	24.37
Five	8.25 ±0.32[b]	9.71 ±0.26[a]	9.79 ±0.36[a]	9.25± 0.12 [d]	24.82
Annual egg no at clutch					
One	45.35 ±0.95[c]	54.49 ±1.05[a]	49.91 ±1.24[b]	49.92 ±03[bc]	24.22
Two	50.38 ±0.93 [b]	56.08 ±1.03[a]	54.74 ±1.21 [a]	53.73±0.61[b]	22.01
Three	58.76± 2.33[b]	63.67 ±2.57[ab]	68.97± 3.04[a]	63.80 ±1.54[a]	40.76
Four	41.51± 1.50[b]	49.27 ±1.65[a]	53.16 ±1.95[a]	47.98±0.99 [c]	40.29
Five	13.42± 1.92[b]	28.89 ±2.12[a]	22.52±2.50[a]	21.61± 1.27[d]	46.13

LS-means with the same letter are not significantly different (p>0.05)

4.4.3. Inbreeding and effective population size

The result of the survey revealed that the effective population size (Ne) of the chicken flock under farmers' management conditions of the lowland agro-ecology was 480.26 which was slightly higher than from highland (315.86) and midland (449.34) agro-ecologies (Table 39). However, the rate of change of inbreeding coefficient (ΔF) of lowland chicken population was 0.104% which was lesser than from midland (0.111%) and highland (0.16%) since there was collection of breeding chickens from various origins and thus widens the chance of mating among unrelated chickens in lowland which is the investment zone of the study area. The effective population size (Ne) and the rate of change of inbreeding coefficient (ΔF) of chicken flock under farmers' extensive management was 1263.69 and 0.04%, respectively in the study area which indicated that the population was not at the risk of consequences of the rate of inbreeding. This result was comparable with the findings of Yakubu *et al*. (2013) who reported that the effective population size (Ne) and the rate of inbreeding (ΔF) for the Nigerian indigenous turkey flock considering the existing flock size and management practice was 396 and 0.13%, respectively. However, it was much higher than the effective population size of (3.9 and 15.35) and the rate of change in breeding coefficients of local chickens (12.82% and 5.25%), respectively reported by Bogale (2008) and Abdelqader *et al*. (2007) in Fogera district of Ethiopia and in the rural areas of northern districts of Jordan, respectively. In Ghana, Hagan *et al*. (2013) also recently reported that the effective population size of the local chickens in the Coastal Savannah, rain forest and guinea savannah were found to be 13.3, 11.3 and 12.9, and 0.038(3.8%), respectively which were lesser than the result of the current study and they obtained similar level of inbreeding coefficients in three of agro-ecologies of Ghana with Coastal (0.038 or 3.8%), Forest (0.044 or 4.4%) and Guinea (0.039 or 3.9%) which were higher than the result obtained in this study.

The effective population size (Ne) of local chickens in all agro-ecologies was within the minimum acceptable level of 100-1000 conservation rule (Frankham *et al*., 2014) and the rate of inbreeding coefficient (ΔF) was lower than the maximum acceptable level of 0.063 (Armstrong, 2006). This indicates existence of genetic variability among local chicken ecotypes and within individuals of each local chicken ecotype. Sustainable and environmentally friendly breeding and conservation programs should be designed and implemented accompanied with training of chicken owners on how inbreeding is avoided through management and its negative impact in reproductive fitness and performances of animals (inbreeding depression).

Table 39: Inbreeding and effective population size

Parameter	Agro-ecological zones							
	Highland		Midland		Lowland		Overall	
	Hens	Cock	Hens	Cock	Hens	Cock	Hens	Cock
Minimum	1	0	1	0	1	0	1	0
Maximum	14	4	15	4	22	4	22	4
Mean ±SD	4.73±2.9	1.02±0.7	5.52±3.1	1.02±0.7	7.13±4.0	0.86±0.8	6.0±3.6	0.95±0.8
Total	445	96	723	133	1141	137	2309	366
Ne	315.86		449.34		480.26		1263.69	
ΔF	0.00158(0.16%)		0.00111(0.111%)		0.00104(0.104%)		0.000396(0.04%)	

Note: Ne: effective population size, ΔF: inbreeding coefficient

4.5. Quantitative Traits of Local Chicken Ecotypes

The overall least square means ± se for quantitative traits of local chicken ecotypes across different agro-ecologies is presented in Table 41.

Effect of agro-ecology on quantitative traits: the result revealed that there was significant ($P<0.05$) differences in all studied quantitative traits except skull width among the three local chicken ecotypes (Table 40). Significantly ($p<0.05$) highest mean values of body length, body weight ,shank length ,comb length, beak length and wing span was recorded from lowland chicken ecotypes followed by midland while the least figures were obtained from highland chickens. In the same context, significantly ($p<0.05$) maximum values of comb width, earlobe length; wattle length, wattle width, beak width and spur length were obtained from lowland chicken ecotypes followed by highland whereas the least values were recorded from midland chicken ecotypes. However, significantly (P<0.05) highest values of comb index and earlobe index were recorded from midland chicken ecotypes followed by lowland but the least values were obtained from highland chicken ecotypes. Similar values of earlobe width, wattle index and neck length were obtained from both lowland and highland chicken ecotypes in which their values in earlobe width was significantly (p<0.05) higher than from midland chicken ecotypes but their values in both neck length and wattle index were significantly lower than from midland chicken ecotypes. Comparable values of skull index and skull length were obtained from both midland and highland chicken ecotypes in which their values were significantly (p<0.05) higher than lowland chicken ecotypes.

Effect of sex on quantitative traits: the analysis of morphometric traits indicated there was significant (p<0.05) effect of sex on all considered quantitative traits except earlobe index (Table 41). Male chickens had significantly (p<0.05) higher mean values of all studied traits except wattle and beak indices than female chickens whereas significantly (p<0.05) higher values of wattle and beak indices were obtained from females than male local chickens. However, similar values of earlobe index were obtained from both local chicken sexes.

Sex by agro-ecology interaction effect on quantitative traits: the analysis of quantitative traits of local chicken showed that sex by chicken ecotypes interaction had significant (p<0.05) effect on all studied quantitative traits (Table 41). Significantly (P<0.05) highest mean values of body length (39.53±0.09 cm), body weight (1.676±0.0l kg), shank length (12. 93±0.5 cm), comb length (7.50±0.04 cm), beak length (2.23±0.2 cm) and wing span (47.52±0. 014 cm) were obtained from lowland male chicken ecotypes and followed by midland male (3 6.08±0.10 cm, 1.579±0.01kg, 10.81±0.06 cm, 6.78±0.04 cm, 2.07±0.02 cm and 40.1±0.15 cm respectively) while the least values (32.50±0.02 cm, 1.451±0.01kg, 9.87±0.06 cm, 5.49±0.05 cm, 1.99±0.02 cm and 36.80±0.18 cm respectively) were recorded from highland male chicken ecotypes. Comparable values of body length (39.97±0.35 cm Horro male & 36.13±0. 35 cm Jarso male), body weight (1.69±0.03 kg Horro male &1.41±0.04 kg Jarso male) and shank length (11.32±0.10 cm Horro male & 9.99 ±0.12 cm Jarso male) have been reported from Horro and Jarso districts of Oromia (Eskindir *et al*.,2013). This result was also in agreement with the findings of Bogale (2008) and Halima (2007) who reported that the average values of shank length of local cock in Fogera district (9.8 cm) and Northwest Ethiopia (10.31cm) respectively. Similarly, Nigussie *et al*. (2010a) reported that the overall shank length and body weight of male mature indigenous chicken populations of five districts (Farta, Mandura, Horro, Konso and Sheka) of Ethiopia were (9.1±1.1cm &1612±458 gm). Th is result also corroborated the findings of Emebet *et al*. (2014) who reported that shank length, body length and body weight of Dawo, Seden sodo, Mahale Amebe and Mehurena Akile indi genous chickens were (9.8 cm, 10.5 cm, 12.2 cm and 10 cm), (28cm, 30.85cm, 33.55 cm & 28 .83 cm) & (1297.18 gm, 1380.33 gm, 1955.0 gm & 1013.46 gm), respectively in four districts of South West and South part of Ethiopia. However, the current results on wing span local cock were much higher than those reported from North West Ethiopia (15.38 cm) (Halima, 2007) and Fogera district (15.88±0.51 cm) (Bogale, 2008) but much lower than 77.87 ±0.65cm Horro cock & 70.96 ±0.73 cm Jarso cock reported by Eskindir *et al*. (2013) in Horro and Jarso districts of Oromia regional state of Ethiopia and from Spain by Francesch *et al*. (2011) that indicated that the average wingspan of Penedesenca and Empordanesa chicken breeds were 76.405±0.05 cm and 75.84±0.05 cm, respectively.

Likewise, highest mean values of comb width (3.81±0.02 cm), earlobe length (3.55±0.01cm), earlobe width (2.19±0.01cm), spur length (2.44±0.01cm), wattle length (6.21±0.05cm) and wattle width (3.93±0.04 cm) were recorded from lowland male chicken ecotypes and followed by highland whereas the values were obtained from midland male chicken ecotypes. In contrast, significantly ($p<0.05$) highest mean values of comb index (2.44±0.02) and neck length (16.93±0.08cm) were obtained from midland male chicken ecotypes followed by lowland but the least values were recorded from highland male chicken ecotypes. Similarly, similar mean values of earlobe index, skull length and beak index were recorded from both lowland and highland male chicken ecotypes in which their values were significantly lower than the values (1.96±0.02, 7.04±0.08 cm and 2.17±0.03) of midland male chicken ecotypes. Comparable values of beak width were obtained from both midland and highland male chicken ecotypes which were significantly ($p<0.05$) lower than values of lowland male chicken ecotypes (1.24±0.01cm). On the contrary, mean values of skull width were similar in both lowland (4.18±0.05 cm) and midland (4.18±0.06 cm) male chicken ecotypes and their values were significantly higher than highland male chicken ecotypes. However, mean values of wattle and skull indices were similar among the three male chicken ecotypes. This result corroborated the findings of Francesch *et al*. (2011) who reported that the mean values of skull length, skull width, comb length, comb width, beak length and beak width of Penedesenca and Empordanesa chicken breeds in Spain were 5.014±0.93 cm &4.946±0.93 cm , 2.499±0.30 cm & 2.725±0.30 cm, 6.205±1.59 cm&7.231±1.59 cm, 3.541±1.59 cm &3.956± 1.59 cm, 2.016±0.14 cm & 1.90±0.30 cm and 1.212±0.14 cm & 1.279±0.14 cm respectively. Moreover, comparable values of comb length (5.88±0.12 cm Horro cock &5.64±0.14 cm Jarso cock) have been reported from Horro and Jarso districts of Oromia (Eskindir *et al*. (2013).

Furthermore, Addis *et al*. (2014) also reported similar overall mean values of wingspan (38.09±0.24cm), body length (36.77±0.03cm), beak length (2.09±0.03cm) and body weight (1.63±0.03kg) of local cock in North Gondar but lower overall mean values of shank length (8.08±0.11cm), comb length (3.16±0.07cm), comb width (2.08±0.07cm), wattle length (2.43±0.07cm) and wattle width (2.17±0.09cm) of local cock in three districts (Quara, Alefa & Tache Armacheho) of North Gondar.

In the same way, significantly ($p<0.05$) highest mean values of wing span (36.05±0.13 cm) and shank length (8.81±0.048 cm) were obtained from lowland female chicken ecotypes followed by midland (34.39±0.14 cm & 8.29±0.05cm respectively) while least values of wing span (32.83±0.16 cm) were obtained from highland female chicken ecotypes but both midland and highland female chicken ecotypes had similar shank length mean values (8.29±0.05 cm Vs 8.27±0.06 cm). However, significantly maximum mean values of earlobe length (1.88±0.02 cm) and width (1.23±0.02 cm) were recorded from highland female chicken ecotypes and followed by lowland (1.63±0.01 cm & 0.91±0.01cm respectively) while the least mean values (1.27±0.01 cm & 0.71±0.02 cm respectively) were obtained from midland female chicken ecotypes. However, statistically highest mean values of body length were obtained from midland female chicken ecotypes (24.92±0.09 cm) followed by lowland female chicken ecotypes (24.23±0.09 cm) but least values (23.82±0.11 cm) were recorded from highland female chicken ecotypes. Similar means of comb length (2.73±0.03 cm lowland hen &2.78±0.04 cm highland hen), comb index(1.87±0.02 lowland hen & 1.89±0.02 highland hen), wattle width (1.38±0.04 cm lowland hen & 1.39±0.05 cm highland hen), wattle index (1.61±0.03 lowland hen &1.52±0.05 highland hen), beak width (1.08±0.01cm lowland hen & 1.03±0.02 cm highland hen) and beak index (1.97±0.03 lowland hen & 2.01±0.03 highland hen) were recorded from both lowland and highland female chicken ecotypes in which their values of comb length, comb index, wattle width and beak width were significantly ($p<0.05$) higher than values of midland female chicken ecotypes (2.57±0.04 cm, 1.71±0.02, 1.08±0.04 cm & 0.93±0.02 cm respectively) but their values of beak index and wattle indices were significantly lower than values from midland female chicken ecotypes (2.35±0.03 & 2.02±0.03 respectively). Mean values of body weight and earlobe index were similar between lowland (1.272±0.09 kg & 1.84±0.02) and midland (1.270±0.01 kg &1.84±0.02) female chicken ecotypes which were significantly ($p<0.05$) higher than values of highland female chicken ecotypes (1.192±0.01 kg & 1.57±0.03). Mean values of skull length were comparable in both highland (6.38±0.08 cm) and midland (6.27±0.07 cm) female chicken ecotypes which were significantly higher than values (5.78±0.06 cm) of female chickens from lowland. However, mean values of comb width, wattle length, skull width, skull index, neck length, beak length and spur length were similar among the three female chicken ecotypes.

Similar mean values of body length (35.16±0.27 cm for Horro hen & 32.66±0.26 cm for Jarso hen), comb length (2.37±0.10 cm for Horro hen & 2.53±0.09 cm for Jarso hen), shank length (9.22±0.08 cm for Horro hen & 8.51±0.08 cm for Jarso hen) and body weight (1.29±0.02 kg for Horro hen & 1.12±0.02 kg for Jarso hen) have been reported from Horro and Jarso districts of Oromia regional state (Eskindir *et al.*,2013).This result also somewhat corroborated the findings of Nigussie *et al*. (2010a) who reported that the overall shank length and body weight of female mature indigenous chicken populations of five districts (Farta, Mandura, Horro, Konso & Sheka) of Ethiopia were 7.0±0.7 cm and 1266±373gm, respectively. Furthermore, comparable results on shank length of local hens have been also reported from North West Ethiopia (8.14 cm) by Halima (2007) and Fogera district (7.25±0.16 cm) by Bogale (2008). However, the current results on wing span of local hens were much higher than those reported from North West Ethiopia (13.36 cm for hens) (Halima, 2007) and Fogera district (12.57±2.11 cm for hens) (Bogale, 2008) but much lower than those reported from Horro (69.96±0.51 cm for females) and Jarso (62.58±0.49 cm for females) by Eskindir *et al*. (2013) in Horro and Jarso districts of Oromia regional state of Ethiopia. This result was also in parallel with the findings of Addis *et al*. (2014) who reported that the overall mean values of wingspan (36.52±0.14 cm), body length (35.29±0.16 cm), beak length (1.99±0.02 cm), shank length (7.64±0.07 cm), comb length (2.55±0.13 cm), comb width (1.48±0.04 cm), wattle length (1.42±0.07 cm), wattle width (1.18±0.07 cm) and body weight (1.37±0.02 kg) of local hens in three districts (Quara, Alefa & Tache Armacheho) of North Gondar.

In Nigeria, Yakubu *et al*. (2009) reported similar figures on beak length and body length of female (1.95±0.02 cm and 26.56±0.17cm) and male (2.12±0.04 cm and 28.67±0.40 cm) Nigerian indigenous chickens. However, lower figures on body weight (1.37±0.04 kg for males and 1.19±0.02 kg for females), neck length (8.9±0.2 cm for males and 7.81±0.12 cm for female) and shank length (6.65±0.12 cm for males and 6.25±0.05 cm for females) have been reported in Nigeria by the same authors and time. In Nigeria, Mandisa (2012) found that higher mean values of body weight in the indigenous Nigerian breeds of Black Australorp (3.0±0.08 kg), Ovambo (2.4± 0.09 kg), Potchfstroom Koekoek (2.5±0.08 kg) and Venda (2.7±0.10 kg). However, he reported comparable mean values of comb height/width (46.3±2.09 mm, 38.2±2.20 mm, 38.9±2.09 mm & 40.5±2.49 mm), comb length (91.4±3.36 mm, 83.3±3.54 mm, 74.1±3.36 mm & 81.0±4.0 mm), beak length (20.0±0.78 mm, 17.5±0.82 mm, 17.2±0.78 mm & 19.4±0.92 mm), body length (26.2±0.55 cm, 24.5±0.58 cm, 23.2±0.55 cm & 25.7±0.66 cm), neck length (16.6±0.70 cm, 17.9±0.73 cm, 13.1±0.70 cm & 16.8±0.83 cm) and shank length (13.8±0.42 cm, 8.75±0.44 cm, 8.7±0.42 cm & 9.3±0.50 cm) of the Nigerian indigenous breeds of Black Australorp, Ovambo, Potchfstroom Koekoek and Venda respectively. However, Guni & Katule (2013) reported lower mean values of shank length of hens (6.19±0.03 cm) and cock (7.96±0.05 cm) of Tanzanian indigenous chickens but they reported higher average values of body weight (2095±29.9 gm for cock & 1525±15.9 gm for hens), body length (45.7±0.23 cm for cock & 40.2±0.12 cm for hens) and wing span (51.5±0.27 cm for cock & 43.8±0.14 cm) in three districts (Chunya, Njombe & Songea) of southern highlands of Tanzania. Daikwo *et al*. (2011) reported somewhat similar mean values of body weight (1.32±0.02 kg for local cock & 1.05±0.01 kg for local hens), body length

(38.45±0.50 cm for local cock & 33.87±0.45 cm for local hens) and beak length (2.21±0.07 cm for local cock & 1.65±0.04 cm for local hens) but lower values of shank length (6.23±0.13 cm for local cock & 4.89±0.12 cm for local hens) and comb length (2.46±0.10 cm for local cock & 1.71±0.08 cm for local hens) in Denkia local Government Area of Kogistate of Nigeria. In the same way, Apuno *et al*. (2011) also reported slightly similar values of body weight (1.34± 0.04 kg for local cock & 1.18±0.03 kg for local hens) and shank length (9.69±0.07 cm for local cock & 7.87±0.05 cm for local hens) but lower values of body length (18.63± 0.14 cm for local cock & 17.81±0.12 cm for local hens) in Shelleng and Song local government areas of Adamawa state of Nigeria. In contrast, Al-Qamashoui *et al*. (2014) reported lower values for body weight (1.33±0.65 kg for local cock & 1.17±0.86 kg for local hens), body length (18.4±0.14 cm for local cock & 17.3±0.13 cm for local hens) and shank length (8.1±0.11cm for local cock & 7.1±0.14 cm for local hens) in the six agro-ecological zones of Oman.

The analysis of quantitative traits of local chicken ecotypes of western Zone of Tigray confirmed that significant variations in most of studied quantitative traits among the three indigenous chicken (lowland, midland & highland) ecotypes. This morphological/phenotypic variability of indigenous chickens of the zone is a major indicator for the existence of high genetic variability among the three local chicken ecotypes of the zone which serve as a big potential for genetic improvements of the indigenous chicken ecotypes through appropriate genetic improvement methods.

The phenotypic discrepancies in quantitative traits is an indication of their genetic differences existed in these traits among the three chicken ecotypes studied. This is due to the variations in the agro ecological variables/elements/ (altitude, rainfall, temperature, humidity, production system variables and others) which make different production environments in different agro-ecological zones. This will create an opportunity to evolve new breeds/strains from either different or related populations of the same animal species through time with different levels of performances through natural selection in order to cope with environmental changes, new diseases, pest epidemics and others. Moreover, this could be due to the presence of geographical isolation among the chicken ecotypes. That is a population of a species becomes separated by physical barrier (river, mountain range, lake, ocean, etc) and allowing each sub populations of the species to adapt different environments with different selection pressures and their genetic differences/divergence will gradually become more and more distinct as time goes so that the subpopulations will no longer interbreed (to remain reproductively isolated for ever). Finally, they become different breeds/strains of the species. The variability observed in this cross-sectional study could be used in designing community based genetic improvement in a situation where livestock record is lacking under village chicken production system.

The sex differences with respect to quantitative traits were in agreement with reports from Ethiopia (Eskindir *et al*., 2013; Emebet *et al*., 2014 & Addis *et al*., 2014) and South Africa (Alabi *et al*., 2012) and Nigeria (Falasade & Obinna, 2009). That can be explained due to Sexual dimorphism (Alabi *et al*., 2012; Falasade & Obinna, 2009) which are attributable to differential effects of hormones (Androgen & estrogen) (Yakubu *et al*., 2009) in addition to other factors.

Table 40: Effect of agro-ecology on quantitative traits of local chicken ecotypes in western zone of Tigray (Lsmeans ±SE)

Traits	Agro-ecological zones			
	Lowland (N = 310)	Midland (N = 260)	Highland (N = 200)	CV
Body length (cm)	31.88±0.06[a]	30.50±0.07 [b]	28.16± 0.08 [c]	3.72
Body weight(kg)	1.474±0.004[a]	1.425± 0.005[b]	1.346±0.005[c]	5.34
Shank length (cm)	10.37±0.03[a]	9.55± 0.04[b]	9.07±0.04[c]	6.24
Comb length (cm)	5.11± 0.026[a]	4.46± 0.029[b]	4.13± 0.033[c]	10.1
Comb width(cm)	2.64± 0.01[a]	2.13± 0.01[c]	2.28± 0.02[b]	9.47
Comb index	1.93± 0.01[b]	2.07±0.02[a]	1.84± 0.02[c]	13.22
Earlobe length(cm)	2.59±0.01[a]	1.90±0.01[c]	2.47± 0.01[b]	7.85
Earlobe width(cm)	1.55± 0.01 [a]	1.01± 0.01 [b]	1.55±0.01 [a]	13.92
Earlobe index	1.74± 0.02 [b]	1.90±0.02[a]	1.61±0.02[c]	15.65
Wattle length (cm)	4.16± 0.03 [a]	3.24±0.04 [c]	3.69± 0.04[b]	16.83
Wattle width(cm)	2.66±0.03 [a]	1.92±0.03 [c]	2.38± 0.03[b]	21.69
Wattle index	1.61±0.02[b]	1.86± 0.02[a]	1.59± 0.02[b]	20.82
Skull length(cm)	6.20±0.05[b]	6.66± 0.05 [a]	6.51± 0.06 [a]	12.91
Skull width(cm)	3.79± 0.04[a]	3.85± 0.04[a]	3.73±0.04[a]	16.57
Skull index	1.70± 0.01[b]	1.77± 0.02 [a]	1.77± 0.02 [a]	14.54
Neck length(cm)	14.71± 0.05[b]	16.27±0.06[a]	12.93±0.06[b]	6.30
Beak length(cm)	2.13± 0.01[a]	2.07± 0.01[b]	2.02±0.01[c]	9.29
Beak width(cm)	1.16±0.01[a]	0.95±0.01[c]	1.04±0.01[b]	16.98
Beak index	1.88±0.02[c]	2.26±0.02[a]	1.97±0.03 [b]	17.81
Spur length(cm)	1.43±0.01[a]	0.93±0.01 [c]	1.14±0.01[b]	13.48
Wing span(cm)	41.79±0.10[a]	37.20± 0.10[b]	34.81±0.12[c]	4.31

LS-means with the different letter in the same row are significantly different ($p<0.05$).

N = number of sampled matured local chickens per agro-ecology

Table 41: Least squares for quantitative traits of local chicken ecotypes in three agro-ecological zones of western zone of Tigray (Lsmeans ±SE)

Traits	Sex of chicken	Lowland (N = 310)	Midland (N = 260)	Highland (N = 200)	Total	Overall (N = 770)	CV
Body length (cm)	Male	39.53 ± 0.09[a]	36.08 ± 0.10[b]	32.50± 0.12[c]	36.04±0.06 [a]	30.18±0.04	3.72
	Female	24.23 ±0.09[e]	24.92±0.09[d]	23.82±0.11 [f]	24.32±0.06 [b]		
Body wt(gm)	Male	1.676±0.01[a]	1.579±0.01[b]	1.451±0.01[c]	1.569±0.004[a]	1.415±0.003	5.34
	Female	1.272±0.01[d]	1.270±0.01[d]	1.192±0.01[e]	1.261±0.004[b]		
Shank length (cm)	Male	12.93 ±0.05[a]	10.81±0.06[b]	9.87±0.06[c]	11.20± 0.03[a]	9.83±0.023	6.24
	Female	8.81±0.05[c]	8.29±0.05[e]	8.27 ±0.06[e]	8.46± 0.03[b]		
Comb length (cm)	Male	7.50 ±0.04[a]	6.68±0.04[b]	5.49 ±0.05[c]	6.55±0.02[a]	4.62±0.02	10.1
	Female	2.73±0.03[d]	2.57±0.04[e]	2.78 ±0.04[d]	2.69± 0.02[b]		
Comb width(cm)	Male	3.81 ±0.02[a]	2.75 ±0.02[c]	3.09±0.02[b]	3.22±0.01[a]	2.35±0.01	9.47
	Female	1.47 ±0.02[d]	1.51±0.02[d]	1.47 ±0.02[d]	1.48±0.01[b]		
Comb index	Male	1.98 ±0.02[b]	2.44 ±0.02[a]	1.78 ±0.03[de]	2.07± 0.01[a]	1.95±0.01	13.22
	Female	1.87±0.02[cd]	1.71 ±0.02[e]	1.89±0.02[bc]	1.83±0.01[b]		
Earlobe length (cm)	Male	3.55 ±0.01[a]	2.53 ±0.02[c]	3.06 ±0.02[b]	3.05±0.01[a]	2.32±0.01	7.85
	Female	1.63±0.01 [e]	1.27±0.01[f]	1.88±0.02[d]	1.59±0.01[b]		
Earlobe width(cm)	Male	2.19±0.02 [a]	1.32 ±0.02[c]	1.86 ±0.02[b]	1.79± 0.01[a]	1.37±0.01	13.92
	Female	0.91 ±0.01[e]	0.71 ±0.02[f]	1.23±0.02 [d]	0.95±0.01[b]		
Earlobe index	Male	1.64±0.02[c]	1.96± 0.03[a]	1.66 ±0.02[c]	1.75± 0.01[a]	1.75±0.01	15.65
	Female	1.84 ±0.02[b]	1.8 4 ±0.02[b]	1.57 ±0.03[c]	1.75±0.01[a]		
Wattle length (cm)	Male	6.21± 0.05[a]	4.46 ±0.06[c]	5.30 ±0.06[b]	5.32±0.03[a]	3.67±0.02	16.83
	Female	2.12 ±0.05[d]	2.02 ±0.05[d]	2.08± 0.06[d]	2.07 ±0.03[b]		
Wattle width(cm)	Male	3.93± 0.04[a]	2.77 ±0.04[c]	3.37±0.05[b]	3.36±0.03[a]	2.32±0.02	21.69
	Female	1.38±0.04[d]	1.08±0.04[e]	1.39±0.05[d]	1.28±0.02[b]		
Wattle index	Male	1.61±0.02[bc]	1.71 ±0.03[b]	1.66 ±0.04[b]	1.66±0.02[b]	1.69±0.01	20.82
	Female	1.61± 0.03[bc]	2.02 ±0.03[a]	1.52 ±0.05[c]	1.71±0.02[a]		

Ls means with different superscripts are significantly different ($p<0.05$)

Table 41 (continued)

Traits	Sex of chicken	Lowland (N = 310)	Midland (N = 260)	Highland (N = 200)	Total	Overall (N = 770)	CV
Skull length(cm)	Male	6.63 ±0.07[b]	7.04 ±0.08[a]	6.63± 0.09[b]	6.77±0.04[a]	6.46±0.03	12.91
	Female	5.78 ±0.06[d]	6.27 ±0.07[c]	6.38 ±0.08[bc]	6.15± 0.04[b]		
Skull width(cm)	Male	4.18 ±0.05[a]	4.18 ±0.06 [a]	3.87 ±0.07[b]	4.08±0.03[a]	3.79±0.02	16.57
	Female	3.41 ±0.05[c]	3.51±0.05[c]	3.59 ±0.06[c]	3.50±0.03[b]		
Skull index	Male	1.64 ±0.02 [c]	1.72± 0.02[bc]	1.73 ±0.03[abc]	1.70±0.01[b]	1.75±0.01	14.54
	Female	1.76 ± 0.02[ab]	1.82±0.02 [a]	1.80 ±0.02[ab]	1.8±0.01[a]		
Neck length(cm)	Male	15.70 ± 0.07[b]	16.93 ±0.08[a]	13.70± 0.09[c]	15.44± 0.05[a]	14.30±0.03	6.30
	Female	13.73±0.07[c]	13.61±0.08[c]	12.15 ±0.09[c]	13.16± 0.05[b]		
Beak length(cm)	Male	2.23± 0.02[a]	2.07± 0.02[b]	1.99 ±0.02[c]	2.10±0.01[a]	2.07±0.01	9.29
	Female	2.03 ±0.02[bc]	2.06±0.02[b]	2.06 ±0.02[bc]	2.05±0.01[b]		
Beak width(cm)	Male	1.24± 0.01[a]	0.97± 0.02[cd]	1.04 ±0.02[bc]	1.08±0.10[a]	1.05±0.01	16.98
	Female	1.08 ± 0.01[b]	0.93 ±0.02[d]	1.03 ±0.02[bc]	1.01±0.01[b]		
Beak index	Male	1.80± 0.03[d]	2.17 ± 0.03[b]	1.93 ±0.04[cd]	1.97±0.02[b]	2.04±0.01	17.81
	Female	1.97 ±0.03[c]	2.35± 0.03[a]	2.01 ±0.03[c]	2.11±0.02 [a]		
Spur length(cm)	Male	2.44 ±0.01[a]	1.48 ±0.01[c]	1.87 ±0.02[b]	1.93± 0.01[a]	1.17±0.01	13.48
	Female	0.42 ±0.01[d]	0.37 ±0.01[d]	0.41± 0.01[d]	0.40± 0.01[b]		
Wing span(cm)	Male	47.52 ±0.14[a]	40.01 ±0.15[b]	36.80 ±0.18[c]	41.44± 0.09[a]	37.93±0.06	4.41
	Female	36.05±0.13[d]	34.39±0.14[e]	32.83±0.16[f]	34.42±0.08[b]		

Ls means with different superscripts are significantly different ($p<0.05$)

Total under the last column indicates effect of sex on quantitative traits.

N = number of sampled matured local chickens per agro-ecology

4. 6. Qualitative Traits

Of the total chicken population studied only 16.1% were identified as blocky bodied, the remaining chickens had wedge body shape. The distribution of both blocky and wedge bodied chickens differed between sexes but not among agro-ecologies (Table 42). Higher proportion of both blocky and wedge bodied chickens were observed more in females than males. Although the distribution of chickens with block and wedge body shape were not significantly different among the agro-ecologies, slightly higher proportion of both wedge and blocky bodied chickens were found in the lowland agro-ecology. This result was close to the ones reported (80% wedge and 11% blocky body shape) by Bogale (2008) in the Fogera chicken population.

The proportion of chickens with spur (56.8%) was more frequent than the proportion of chickens without spurs (43.2%). However, the distributions of chickens with and without spur were not significantly different among agro-ecologies and sexes. This result was slightly agrees with the report of Bogale (2008) in which 71% and 29% of the Fogera chicken population had spurs and no spurs, respectively.

The occurrence of crest headed chickens (55.8%) was more frequent than plain headed chickens in the study area even though plain and crest headed chickens were not significantly differed between sexes and among agro-ecologies (Table 42). This result was comparable with the report that 51.8% plain headed and 48.8% crest head were found in North West East (Halima, 2007). However, it was much lower from 7% plain headed , 93% crest headed chickens reported in Fogera district (Bogale,2008), 28.83% crest headed and 71.7% plain in Horro district, and 4.59% crest headed and 95.41plain headed chickens in Jarro district (Eskindir *et al.*,2013), and 82.22% plain headed & 17.78% crest wasreported in Nigeria (Egahi *et al.*, 2010).

The predominantly frequent comb size of local chickens was small (59.7%) while large (27.5%) and medium (12.9%) were the second and third comb sizes of local chickens, respectively in the study area (Table 42). Differences were not observed among the three agro-ecologies with respect to comb size but comb size distribution was significantly different between both chicken sexes. Large comb (27.2%) was the first most frequent comb size of male local chickens and followed by medium (6.1%) and small size (2.6%). Whereas small comb (57.1%) was the first predominant comb size in female local chickens while medium comb (6.8%) was the second frequent comb size. The frequency of large comb size (0.2%) in female chickens was very rare. Likewise, Guni & Katule (2013) reported that 54.5%, 29.6% and 15.9% of the Tanzanian chicken populations to be small, medium and large comb sized chickens, respectively. The same author also reported that small (51.8%) and medium (22.2%) were found to be most predominant comb sizes in female chickens, and large (12.3%) and medium (7.36%) comb sizes were most frequently observed comb sizes in male chicken populations in Tanzania.

Regarding to feather distribution, normal feathered chickens (92%) were most frequent while the occurrences of necked neck chickens (8%) was very rare in the study area. Significant variations with respect to distributions of both normal feathered and necked neck chickens were observed among the agro-ecologies. The frequency of necked neck chickens was less frequent than normal feathered chickens in all three agro-ecologies .However, the frequency of necked neck chickens in the lowland agro-ecology was much higher (7% of the total chicken population) than in both midland (0.7%) and highland agro-ecology (0.1%). Because they are highly adaptable to a very hot ecological zones (lowland) than cold (both high land & midland) zones (Addis *et al*., 2014). This might be due to their necked-neck character which is described as the expression of the major gene found in local chicken populations of the tropics and has desirable effects on heat tolerances (Horst, 1989). Moreover, the rare occurrences of the necked-neck chickens might be an indication of a negative selection against this character. No significant variations in both distributions of necked-neck and normal feathered chickens were observed between male and female chickens. The proportion of necked –neck chickens in this study was higher than (0%) reported from Fogera district of Ethiopia (Bogale, 2008), from five (Farta, Mandura, Horro, Konso and Sheka) districts of Ethiopia (2%) (Nigussie *et al*., 2010a) and from Tanzania (5.48%) (Guni & Katule, 2013).

Agro-ecologies significantly differed with respect to comb types but the proportions of all identified comb types were not statically different between both chicken sexes (Table

42). Overall, Rose comb type appeared most frequent (53.3%) followed by single (24.4%), pea (17.7%), walnut/ straw berry (2.7%) and Duplex /v-shape, double/ (1.9%). Rose comb type was the most common (53.3%) comb type and was predominant in all agro-ecologies and sexes. Similarly, Bogale (2008) reported that Rose comb type (53%) was predominant comb type of local chicken populations in Fogera district. Eskindir *et al*. (2013) also recently reported that Rose comb type (48.2%) was predominant in Horro chicken ecotypes in Horro districts. However, Halima (2007), Nigussie *et al*. (2010a) and Eskindir *et al*. (2013) observed 50.72%, 53% and 33.49% of chickens in North West Ethiopia, five (Farta, Mandura, Horro, Konso and Sheka) districts and Jarso districts of Ethiopia to be pea comb type, respectively. Faruq et *al*. (2010), Egahi *et al*. (2010) and Guni & Katule, 2013) observed 100%, 43.33% and 87.4% of chickens from Bangladesh, Nigeria and Tanzania to be Single comb type, respectively.

Four eye colors (black, orange, brown and red) were observed in this study with marked differences across agro-ecologies and chicken sexes (Table 42). Overall, most (56.5%) of chickens had red eye color, followed by orange (31.9%), brown (10.2%) and black (1.5%). The occurrences of both red-eyed (20.9%) and orange- eyed (12.7%) chickens were higher in lowland than both midland (red eyes (18.6%) and orange eyes (9.2%)) and highland (red eyes (16.9%) and orange eyes (9.9%) agro-ecologies. Both red-eyed (33.7%) and orange-eyed (21.6%) chickens were more frequent in females than in males (22.7% red-eyed and 10.2% orange-eyed). In contrast, Duguma (2006) reported that 100% of the chickens were found to be black-eyed chickens in Debrezeit Agricultural Research Center of Ethiopia. Eskindir et *al*. (2013) also observed 87.84% and 9.01%, 72.48% and 24.31% of chickens of Horro and Jarso districts of Ethiopia to be orange and red eye colours, respectively. Orange eye (73.4%) and brown eye (16.3%) colors were found to be the first and second most frequent eye colors in Tanzanian chicken populations (Guni & Katule, 2013). Variation in eye colors to a large extent depends on the pigmentation (carotenoid pigments) and blood supply to a number of structures with the eye (Crawford, 1990).

The first predominantly frequent skin color in the studied chicken populations was white (99%) while the remaining yellow (0.5%), red (0.4%) and pink (0.1%) were the least frequent skin colors. Significant differences were observed among agro-ecologies with respect to skin colors but not between chicken sexes (Table 42). Both lowland and midland agro-ecologies had higher occurrences of chickens with white skin (37.3% and 33.3% respectively) than highland agro-ecology (28.4%). Similarly, Eskindir *et al*. (2013) observed that (77.03%) and (22.07%), and 68.81% and 28.44% of the chickens were found to be white and yellow – skinned chickens in Horro and Jarso districts of Ethiopia, respectively. Similar results have been reported from Tanzania (Guni & Katule, 2013) where white skin color seemed to be more frequent (51.2%) than yellow (48.8%). In contrary, Bogale (2008) reported that bluish black (45%) and white (32%) were the first and second frequent skin colours of chickens in Fogera district. Duguma (2006) also observed red (83.1%) was the first predominant skin colour of chickens in Debrezeit Agricultural Research Centre. Addis *et al*. (2014) also recently reported that 53.1% and 42.9% of the chickens were found to be chickens with yellow and white-skin colours in North Gondar Zone of Ethiopia, respectively. Yellow (52%) and white (48%) skin colours were found to be the first and second predominant skin colours of chickens in Ethiopia (Nigussie *et al.*, 2010a). The variations in skin colours observed among agro-ecologies might be due to differences in feedstuffs availability of chickens in the respective agro-ecologies. According Eriksson *et al*. (2008) white skin color is the result of the absences of carotenoid pigments while yellow skin color is the result of presences of Carotenoid pigments (Xanthophylls) which are consumed through feeds and deposited under skin. This could also be due to different genetic determination. Even if chickens are exposed to diets containing carotenoid, some chickens may be unable to deposit the pigment under skin.

The proportions of plumage color attributes were significantly different across agro-ecologies and chicken sexes (Table 43). Red plumage color was the predominantly frequent plumage color in all agro-ecologies and sexes. Overall, red plumages appeared most frequently (51.2%) and followed by *Gebsima* (grayish) (18.2%), *Anbesima* (multicolor) (8.9%), *Netch Teterma* (5.2%), white (4.7%) and *Key Teterma* (4%). Whereas *zagrama* (2.3%), black (2%), *Kokima* (1.5%), *Seran* / white with red spots / (1.2%) and *Tikur*/ black/ *Teterma* (1%) were the rarely occurred plumage colors across agro-ecologies and chicken sexes.

Similar results have been reported from Fogera districts (Bogale, 2008), Debrezeit Agricultural Research Center (Duguma, 2006) and North Gondar Zone of Ethiopia (Addis *et al*., 2014) where red plumage color seemed to be more frequent (39%, 20.8% and 26.9%, respectively) than others. However, contrasting results have also been reported from North West Ethiopia (Halima, 2007), five (Farta, Mandura, Horro, Konso and Sheka) districts (Nigussie *et al*., 2010a) and North Wollo Zone (Addisu, 2012) where white plumage colored chickens (25.49%, 18% and 17.6%, respectively) were found to be the most predominantly frequent. Faruq *et al.* (2010) and Egahi *et al.* (2010) also reported that black plumage color (33.3% and 32.22%, respectively) was the predominantly frequent plumage color of chickens in Bangladesh and Nigeria, respectively. Contrasting results have also been reported from Tanzania (Guni & Katule, 2013) where multicolored plumages appeared most frequently (50.8%) followed by black (18.6%), brown (9.81%) and white (8.37%). The occurrences of diversified plumage colors of local chicken populations across the three agro-ecologies might be the result of uncontrolled breeding of chickens in the rural areas since random mating is a typical breeding practice under scavenging production system. Diversified plumage colors could be serving as a bright future for improvement of genetic potential of local chicken ecotypes through selection. The reason for the higher occurrences of chickens with red plumage colors might be people under the study area prefer to rear chickens with red plumage colors as they have higher market demand and consumers prefer to consume chicken products of red plumage colored chickens. This is an indication of a positive selection against red plumage color or negative selection against other plumage colors might be practiced.

Significant variations with respect to proportions of breast feather colors were observed among agro-ecologies and both chicken sexes (Table 43). Overall, red color was the most frequent breast feather color (79.5%) and followed by white (10.1%), black (3%), *Zagrama* (2 .3%), *Gebsima* (1.6%), *Anbesima* (1.2%), *NetchTeterma* (1.2%), *Kokima* (0.9%) and *key Teterma* (0.2%). Chickens with red breast feather colors were most frequent across the three agro-ecologies and both chicken sexes.

Various shank colors (yellow, black, white, blue, green and green-blue) were identified in the study area (Table 43). Overall, both white (41.9%) and yellow (41.1%) shank colors were most frequent and followed by green (8%), blue (5.8%), black (2.3%) and Green – blue (1%). There were significant differences with respect to shank colors' proportions among agro-ecologies and between chicken sexes. In both lowland and midland agro-ecologies, the predominant shank color (15.5% and 15.4%, respectively) was white shank color while yellow shank color (14%) was the predominantly frequent shank colors of chicken populations in the highland agro-ecology of the study area.

Similarly, yellow shank color (18.1%) was the most frequent shank color of male chickens where as white shank color (27.2%) appeared to be the predominately frequent shank color of female chicken populations. This result was in line with the results reported by Faruq *et al*. (2010) in Bangladesh that white (35%) and yellow (31%) shank colors were most frequent shank colors of chickens. However, contrasting results have been reported from Fogera districts (Bogale, 2008), North West Ethiopia (Halima, 2007), five (Farta, Mandura, Horro, Konso and Sheka) weredas (Nigussie *et al*., 2010a), Tanzania (Guni & Katule, 2013) and North Gondar zone of Ethiopia (Addis *et al*. , 2014) where yellow shank color was the most predominantly frequent (44%, 64.4%, 60%, 34.7% and 53.1%, respectively) shank colors of local chicken populations. Eskindir *et al*., (2013) has also reported that yellow and white shank colors (79.28% and 60.09% and 16.67% and 25.23%) were the first and second frequent shank colors of local chickens in Horro and Jarso districts of Ethiopia, respectively. It has also reported that chickens with black plumage colors were found to be most frequent chickens in Nigeria (Egahi *et al*., 2010). In general, diversified shank colors of local chicken populations were identified across the agro-ecologies of the study. This could be vital for future genetic improvement of local chicken ecotypes through selection. The occurrence of diversified shank colours might have been due to combinations of pigment controlling genes responsible for colour determination. Petrus (2011) reported that production of carotenoid, dermal melanin and epidermal melanin is controlled by W+ and w; Id and id+; and E and e+ genes, respectively, with the consequent occurrence of various shank colour shades.

Diversified back feather colors of local chicken ecotype (white, black, red, *Gebsima*, *Anbesima*, *Key Teterma*, *Netch Teterma*, *Kokima*, *Seran*, *Zagrama* and black *Teterma*) were identified in the study area (Table 44). Overall, most of the local chicken ecotypes observed in the study area had red (51.2%) back feather color followed by *Gebsima* (18%) and *Anbesima* (9%). The remaining back feather colour types observed were *Netch Teterma* (5.2%), white (4.8%), *Key Teterma* (4%), *Zagrama* (2.3%), black (2.2%), *Kokima* (1.4%), *Seran* (1.2%) and black *Teterma* (0.9%), black *Teterma* being the least occurring back feather color. Relatively higher proportions of chickens with red back feather color were found in lowland agro-ecology (20.6%) than midland (17.8%) and highland (12.8%) agro-ecologies. Equal proportions of chickens with red back feather color (24.6%) were found in both chicken sexes. However, the proportion of chickens with *Gebsima*/grayish back feather color was higher in female chickens (15.9%) than in male chickens (2.1%).

Concerning to neck feather colors, various neck feather colors (white, black, red, *Gebsima*, *Anbesima*, *Key Teterma*, *Netch Teterma*, *Kokima*, *Seran*, *Zagrama* and black *Teterma*) were observed in the study area (Table 44). The occurrences (proportions) of the neck feather color attributes were significantly different among agro-ecologies and both chicken sexes. Overall, most of the chickens had red neck feather colors (67.2%). The second neck feather color was *Gebsima* (9.7%) while 8.3 % and 3.8% of chickens had white and *Anbesima* neck feather colors, respectively. The remaining neck feather color types observed were black (2.9%), *Netch Teterma* (2.7%), *Zagrama* (2.3%), *Key Teterma* (1.6%), *Kokima* (1.3%), *Seran* (0.1%) and black *Teterma* (0.1%) which were rarely occurring neck feather colors of local chicken ecotypes. higher proportions of red neck feather colored chickens were observed in females (39.2%), than males (28%).

Four comb colours (Pale, Red, Black and brown) were observed in this study with a marked difference among agro-ecologies and between chicken sexes (Table 44). Overall, most (61.9%) chickens had pale combs, followed by red combed chickens (37.4%). A higher proportion of pale combed chickens were observed in lowland agro-ecology (23%) than in midland (19.3%) and highland (19.6%) agro-ecologies. Similarly, the proportions of pale combed chickens were higher in females (43.5%) than males (18.5%). Likewise, Duguma (2006) reported that the pale combs (55.1%) were found to be the most frequent comb colours of local chicken ecotypes in Debrezeit Agricultural Research Centre of Ethiopia. However, contrasting results have been reported by Faruq *et al*. (2010) in Bangladesh and by Guni &

Katule (2013) in Tanzania that red combs (55% and 73.9%, respectively) were found to be the first predominant comb colours.

All chickens had earlobes. Differences in earlobe colors were observed among agro-ecologies and between both chicken sexes (Table 42). Generally, most (70.1%) of the chickens had white-red earlobes. The second most frequent earlobe color was red (25.5%) while 3.3 % of the chickens had white earlobes and 1.1% of the chickens had black earlobe which was the least frequent earlobe color. Higher proportions of chickens with white –red earlobes were observed in females (47.6%) than in males (22.5%) chickens. However, relatively higher proportions o chickens with red earlobes were observed in male (13%) than female (12.5%) chickens. This result was in line with the results reported from Fogera districts of Ethiopia that 6o% of the chickens had white-red earlobes (Bogale, 2008) and Eskindir *et al.* (2013) also reported that 49.54% of the chickens had white-red earlobes in Jarso districts of Ethiopia.

Similar results have also been reported from southern highlands of Tanzania that 42.9% of chickens were with white-red earlobe colors (Guni & Katule, 2013). However, contrasting results have been reported from Debrezeit Agricultural Research Center of Ethiopia (Duguma, 2006), Bangladesh (Faruq *et al.*, 2010) and Nigeria (Egahi *et al.*, 2010) that 67%, 68.33% and 73.02% of the chickens had white earlobes, respectively. It has also reported that 44.8% and 52% of chickens in Horro district (Eskindir *et al.*, 2013) and five weredas (Farta, Mandura, Horro, Konso and Sheka) of Ethiopia (Nigussie *et al*., 2010a), respectively, had red earlobes.

Table 42: Proportionate (%) occurrences of body shape, head shape, comb type and size, spur presence and feather distribution, comb type, eye color and skin color of local chicken ecotypes by agro-ecologies and sex

Character	Attributes	Agro-ecology					Sex			
		Lowland (n=619)	Midland (n=548)	Highland (n=475)	Total (n=1642)	X^2-test	Male (n=590)	Female (n=1052)	Total (n=1642)	X^2-test
Body shape	Blocky	6.3	5.4	4.5	16.1		4	12.2	16.1	*
	Wedge	31.4	28	24.4	83.9	ns	32.0	51.9	83.9	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Spur presence	Present	21.9	19.2	15.7	56.8		29.7	27.1	56.8	*
	Absent	15.8	14.1	13.3	43.2	ns	6.2	37	43.2	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Head shape	Plain/*Ebab ras*	17	14.5	12.7	44.2		15.7	28.5	44.2	ns
	Crest/*Cutyo*	20.7	18.9	16.2	55.8		20.2	35.6	55.8	
	Total	37.7	33.4	28.9	100	ns	35.9	64.1	100	
Comb size	Small	22.5	19.9	17.4	59.7		2.6	57.1	59.7	**
	Medium	4.4	5.1	3.3	12.9	ns	6.1	6.8	12.9	
	Large	10.8	8.4	8.2	27.5		27.2	0.2	27.5	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Feather distribution	Normal	30.5	32.6	28.9	92		33.4	58.6	92	ns
	Necked neck	7.2	0.7	0.1	8		2.6	5.5	8	
	Total	37.7	33.4	28.9	100	*	35.9	64.1	100	
Comb type	Rose	17	21.7	14.7	53.3	*	25	28.4	53.3	ns
	Pea	8.5	2.7	6.5	17.7		1.6	16.1	17.7	
	Walnut /strawberry	0.7	0.4	1.6	2.7		0.4	2.3	2.7	
	Single	10.7	8.2	5.5	24.4		7.9	16.4	24.4	
	Duplex /v-shape, double)	0.9	0.4	0.6	1.9		1	0.9	1.9	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n = number chickens observed.

Table 42 (Continued)

Character	Attributes	Agro-ecology					Sex			
		Lowland (n=619)	Midland (n=548)	Highland (n=475)	Total (n=1642)	X^2-test	Male (n=590)	Female (n=1052)	Total (n=1642)	X^2-test
Eye color	Black	1	0.4	0.1	1.5	*	0.2	1.3	1.5	*
	Orange	12.7	9.2	9.9	31.9		10.2	21.6	31.9	
	Brown	3.1	5.2	1.9	10.2		2.8	7.4	10.2	
	Red	20.9	18.6	16.9	56.5		22.7	33.7	56.5	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Skin color	White	37.3	33.3	28.4	99	*	35.3	63.6	99	ns
	Yellow	0.1	0.1	0.3	0.5		0.2	0.2	0.4	
	Red	0.2	0	0.2	0.4		0.4	0.1	0.5	
	Pink	0.1	0	0	0.1		0	0.1	0.1	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n = number chickens observed.

Table 43: Proportionate (%) occurrences of plumage, breast, earlobe and shank colors of local chicken ecotypes by agro-ecologies and sex

Character	Attributes	Agro-ecology					Sex			
		Lowland (n=619)	Midland (n=548)	Highland (n=475)	Total (n=1642)	X^{2}-test	Male (n=590)	Female (n=1052)	Total (n=1642)	X^{2}-test
plumage color	White	1.8	1.0	1.9	4.7	*	1.6	3.1	4.7	*
	Black	1.2	0.5	0.3	2.0		0.2	1.8	2.0	
	Red	20.5	18.0	12.7	51.2		24.7	26.5	51.2	
	Gebsima/grayish	6.7	6.5	5.1	18.2		2.1	16.1	18.2	
	Anbesima/multicolor	2.4	3.2	3.3	8.9		3.5	5.4	8.9	
	Key Teterma	1.4	1.2	1.5	4.0		1.3	2.7	4.0	
	Netch Teterma	1.8	1.6	1.7	5.2		1.5	3.7	5.2	
	Kokima	0.2	0.2	1.0	1.5		0.1	1.4	1.5	
	Seran (white with red spots)	0.7	0.1	0.4	1.2		0.6	0.5	1.2	
	Zagrama	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Black *Teterma*	0.3	0.4	0.3	1.0		0.2	0.8	1.0	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Breast feather color	Black	1.4	0.9	0.7	3.0	*	0.5	2.6	3.0	*
	Red	30.5	27.3	21.7	79.5		30.6	48.8	79.5	
	White	4.2	2.2	3.7	10.1		3.5	6.6	10.1	
	Anbesima	0.1	0.7	0.4	1.2		0.7	0.5	1.2	
	Key Teterma	0.1	0.1	0.1	0.2		0.1	0.1	0.2	
	Gebsima	0.5	0.6	0.5	1.6		0.1	1.6	1.6	
	Zagrama	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Netch Teterma	0.2	0.6	0.4	1.2		0.3	0.9	1.2	
	Kokima	0.1	0.1	0.7	0.9		0	0.9	0.9	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n = number chickens observed.

Table 43(continued)

Character	Attributes	Agro-ecological zones					Sex			
		Lowland (n=619)	Midland (n=548)	Highland (n=475)	Total (n=1642)	X^{2-}test	Male (n=590)	Female (n=1052)	Total (n=1642)	X^{2-}test
Shank color	Yellow	14.8	12.3	14.0	41.1	*	18.1	23	41.1	*
	Black	0.5	0.6	1.1	2.3		0.3	1.9	2.3	
	White	15.5	15.4	10.9	41.9		14.7	27.2	41.8	
	Blue	3.1	2.5	0.2	5.8		0.9	5.0	5.8	
	Green	3.4	1.9	2.7	8.0		1.9	6.1	8.0	
	Green-blue	0.3	0.7	0	1.0		0.1	0.9	1.0	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Feather morphology	Normal	37.7	33.4	28.9	100	ns	35.9	64.1	100	ns
	Others	0	0	0	0		0	0	0	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Feather growth	Fast	37.7	33.4	28.9	100		35.9	64.1	100	
	slow	0	0	0	0	ns	0	0	0	ns
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Earlobe color	White	1.7	1.4	0.3	3.3	*	0.4	3.0	3.3	*
	Red	8.4	8.7	8.3	25.5		13.0	12.5	25.5	
	Black	0.8	0.3	0	1.1		0.1	1.0	1.1	
	White-red	26.8	23.0	20.3	70.1		22.5	47.6	70.1	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Earlobe presences	Absent	0	0	0	0	ns	0	0	0	ns
	Present	37.7	33.4	28.9	100		35.9	64.1	100	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n = number chickens observed.

Table 44: Proportionate (%) occurrences of comb, neck and back colors of local chicken ecotypes by agro-ecologies & sex

Character	Attributes	Agro-ecology					Sex			
		Lowland (n=619)	Midland (n=548)	Highland (n=475)	Total (n=1642)	X^2-test	Male (n=590)	Female (n=1052)	Total (n=1642)	X^2-test
Back feather color	White	1.8	1.0	1.9	4.8	*	1.6	3.2	4.8	*
	Black	1.3	0.6	0.3	2.2		0.3	1.9	2.2	
	Red	20.6	17.8	12.8	51.2		24.6	24.6	51.2	
	Gebsima	6.5	6.5	5.0	18.0		2.1	15.9	18.0	
	Anbesima	2.5	3.2	3.3	9.0		3.6	5.4	9.0	
	Key Teterma	1.4	1.2	1.5	4.0		1.3	2.7	4.0	
	Netch Teterma	1.8	1.6	1.7	5.2		1.5	3.7	5.2	
	Kokima	0.2	0.2	0.9	1.4		0	1.4	1.4	
	Seran	0.7	0.1	0.4	1.2		0.6	0.5	1.2	
	Zagrama	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Black *Teterma*	0.2	0.4	0.3	0.9		0.2	0.7	0.9	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Neck feather color	White	3.4	1.8	3.2	8.3	*	2.5	5.8	8.3	*
	Black	1.5	0.9	0.6	2.9		0.4	2.5	2.9	
	Red	25.6	23.2	18.3	67.2		28	39.2	67.2	
	Gebsima	4	3.5	2.2	9.7		0.6	9.1	9.7	
	Anbesima	0.9	1.6	1.4	3.8		2.3	1.5	3.8	
	Key Teterma	0.5	0.4	0.7	1.6		0.7	0.9	1.6	
	Netch Teterma	1.0	1.0	0.8	2.7		1.1	1.6	2.7	
	Kokima	0.2	0.2	0.9	1.3		0	1.3	1.3	
	Seran	0.1	0	0.1	0.1		0.1	0	0.1	
	Zagrama	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Black *Teterma*	0.1	0	0	0.1		0	0.1	0.1	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	
Comb color	Red	14.3	13.8	9.3	37.4	*	17.5	19.9	37.4	*
	Pale	23	19.3	19.6	61.9		18.5	43.5	61.9	
	Brown	0	0.2	0	0.2		0	0.2	0.2	
	Black	0.4	0	0	0.4		0	0.4	0.4	
	Total	37.7	33.4	28.9	100		35.9	64.1	100	

* ($p<0.05$) & ns ($P>0.05$) at p (0.05) and n = number chickens observed.

4. 7. Carcass Traits of Local Chicken Ecotypes

The least square means ±se for carcass traits for indigenous chickens with age ranging from 10 to 12 months in Western Tigray showed variability across agro-ecologies and sexes (Table 46).

Effect of agro-ecology on carcass traits: the analysis of carcass traits revealed that there was significant ($p<0.05$) differences in all studied traits except skin weight among the three chicken ecotypes (Table 45). Significantly highest mean values of live weight, carcass weight dressing percentage, breast with bone, breast without bone, drumstick weight, back weight, thigh weight, wing weight and neck weight was recorded from lowland chicken ecotypes followed by midland chicken ecotypes while least performances of these carcass traits were obtained from highland chicken ecotypes. However, the three chicken ecotypes recorded similar mean values in skin weight. Moreover, there was also significant ($p<0.05$) effect of agro-ecology on edible giblets (gizzard, liver and heart), shank and paw weights. Superior mean values of gizzard was obtained from lowland chicken ecotypes and followed by midland chicken ecotypes while least mean value was recorded from highland chicken ecotypes. Similarly, least mean values of both heart and liver weights were recorded from highland chicken ecotypes whereas chicken ecotypes from both lowland and midland agro-ecological zones were similarly performed better in both giblets.

Effect of sex on carcass characteristics: the result of carcass trait evaluation indicated that there was significant ($p<0.05$) effect of sex on all studied carcass traits, edible giblets (gizzard and heart), shank and paw weights (Table 46). Male chickens had significantly superior mean values in all considered carcass traits, shank and paw weight, gizzard and heart to female chickens. However, both sexes had similar mean values in liver weight.

Sex and chicken ecotypes interaction effects on carcass traits: the result revealed that sex by chicken ecotypes interaction had significant effect in all considered traits ($p<0.05$) (Table 46). Significantly ($p<0.05$) highest mean values in live body weight, carcass weight, dressing percentage, breast weight with bone, breast without bone, back weight, drumstick weight, thigh weight, wing weight, neck weight and paw weight were obtained from lowland male chicken ecotypes and followed by midland male chicken ecotypes while least performance of these traits were recorded from highland male chicken ecotypes. However, highland male chicken ecotypes performed significantly higher ($p<0.05$) in line with skin weight (109.14±4.1 gm) than lowland (92.80±4.1gm) and midland (81.74±4.1gm) male chicken ecotypes. Both lowland and midland male chicken ecotypes performed equally in both liver and gizzard weights and significantly higher than highland male chicken ecotypes. Similar mean values in heart and shank weights were obtained from all male chicken ecotypes.

In the same way, significantly superior average performance in live body weight, carcass weight, breast weight with bone and thigh weight was recorded from lowland female chicken ecotypes followed by midland female chicken ecotypes while least mean values were observed from highland female ecotypes. Similar performances of breast without bone, drumstick weight, heart weight and wing weight were recorded from both lowland and midland female chicken ecotypes and significantly higher than highland female chicken ecotypes. Neck weight performance of lowland female chicken ecotypes was significantly higher than performance of highland female chicken ecotypes but not different from midland female chicken ecotypes. However, significantly higher mean values in shank weight were obtained from highland female ecotypes than lowland female ecotypes but not different from midland female chicken ecotypes. All female chickens had similar mean values in dressing percentage, skin weight and back weight.

Overall, males were significantly superior to female chickens in all chicken ecotypes with respect to all studied carcass traits in the study area. Lowland chicken ecotypes had superior carcass traits' performances to the rest two chicken ecotypes. This result confirmed that agro ecology caused variations in carcass traits' performances of local chicken ecotypes. This result was somewhat comparable with findings of Bogale (2008) who reported the slaughter weight, carcass weight and dressing percentage of Fogera local cock were 1540gm, 878.6 gm and 58.5% but dissimilar with the slaughter weight (1100gm) , carcass weight (543.8gm) and dressing percentage (49.38%) of Fogera local hens in Fogera district of Ethiopia. Moreover, comparable results have been reported from North Wollo zone (Addisu, 2012) that showed the live weight of male at 24.25±0.04 week's age and female at 23.84±05 week's age were 1500.97 gm and 1253.36 gm. Halima (2007) also reported relatively similar on pre slaughter weight (1044.67±214.97-1517±288.75gm), carcass weight (625.33±272.78-955.33±209.12 gm) and dressing percentage (53.33±0.15-66.67±0.9%) of finisher males but lower values were reported on pre slaughter weight (642±229.68-873.5±499.92gm), carcass weight (387±142.45-570.33±72.57gm) and dressing percentage (56.33±0.08-73.33±0.18) of finisher local females in North West Ethiopia.

Table 45: Effect of agro-ecology on carcass traits of local chicken under scavenging production system of western zone of Tigray (Lsmeans ± SE)

Carcass traits	Chicken ecotypes				
	Lowland (n=16)	Midland (n=16)	Highland (n=16)	Overall (N=48)	CV
Live weight(gm)	1458.22± 13.13[a]	1362.84± 13.13 [b]	1251.96±13.13[c]	1357.67±7.58	3.87
Carcass weight (gm)	980.44±9.47[a]	880.45±9.47[b]	802.68±9.47 [c]	887.86±5.47	4.27
Dressing (%)	66.96 ±0.42[a]	64.39 ±0.42[b]	64.04±0.42[b]	65.13±0.24	2.59
Breast with bone (gm)	256.94 ± 3.53[a]	233.94±3.53[b]	210.02±3.53[c]	233.63 ±2.04	6.05
Breast without bone (gm)	162.09 ±2.15[a]	153.65±2.15[b]	130.61±2.15[c]	148.78 ±1.24	5.77
Back weight(gm)	133.63± 2.17 [a]	116.17±2.17[b]	122.11±2.17[b]	123.97±1.25	7.00
Drumstick weight (gm)	151.11±1.95[a]	142.96± 1.95[b]	119.84± 1.95[c]	137.97±1.13	5.67
Thigh weight(gm)	199.27± 2.74[a]	178.942.74[b]	152.10± 2.74[c]	176.77±1.58	6.19
Wing weight(gm)	137.28± 1.56a	103.53±1.56[b]	126.90± 1.56[c]	122.57±0.90	5.09
Neck weight (gm)	61.49± 1.00[a]	55.31± 1.00 [b]	48.15 ±1.00[c]	54.98±0.58	7.30
Shank weight(gm)	28.79 ±0.83[a]	25.06 ±0.83[b]	29.05±0.83[a]	27.63±0.48	12.00
Skin weight(gm)	86.11±2.86[a]	77.93 ±2.86 [a]	86.094 2.86[a]	83.38±1.65	13.74
Paw weight (gm)	39.37±1.23[a]	35.28±1.23[b]	24.97 1.23 [b]	33.21±0.70	14.65
Giblets					
Liver weight(gm)	28.08 ±0.58 [a]	27.68 ± 0.58 [a]	24.12±0.58[b]	26.63±0.34	8.76
Gizzard weight(gm)	37.79 ± 0.86[a]	33.79 ± 0.861[b]	25.05 ± 0.86[c]	32.21±0.50	10.69
Heart weight(gm)	8.74 ± 0.21 [a]	8.68 ±0.21 [a]	7.75±0.21 [b]	8.39±0.12	10.17

Ls means with different letter in the same row are significantly different (p<0.05)

N = Total number of matured chickens used for carcass evaluation and n = number of chickens used per ecotype.

Table 46: Least square means for carcass traits of local chicken ecotypes at the age of 10-12 months in three agro-ecological zones of western Tigray (Lsmeans ± SE)

Carcass traits		Agro-ecological zones					
	Sex	Lowland (n=16)	Midland (n=16)	Highland (n=16)	Total	Overall (N=48)	CV
Live wt(g)	male	1638.99 ± 18.6^{a}	1527.91± 18.6^{b}	1387.7±18.6^{c}	1518.21 ±10.7^{a}	1357.67±7.6	3.87
	female	1277.45± 18.6^{d}	1197.76± 18.6^{e}	1116.2± 18.6^{f}	1197.14±10.7^{b}		
Carcas.wt(g)	Male	1133.65± 13.4^{a}	1015.54 ±13.4^{b}	899.85 ±13.4^{c}	1016.35 ±7.7^{a}	887.86 ±5.5	4.27
	female	827.23 ±13.4^{d}	745.36±13.4 ^{e}	705.51 ±13.4^{e}	759.36± 7.7^{b}		
Dressing (%)	Male	69.16 ±0.6^{a}	66.47± 0.6^{b}	64.84 ± 0.6^{bc}	66.82± 0.3^{a}	65.13 ±0.2	2.59
	female	64.75±0.6^{bcd}	62.30 ±0.6 ^{d}	63.23± 0.6^{cd}	63.43 ± 0.3^{b}		
Breast wb(g)	Male	294.94 ± 5.0^{a}	270.69 ±5.0 ^{b}	246.70 ±5.0c	270.78 ±2.9^{a}	233.63 ±2.0	6.05
	female	218.94 ± 5.0^{d}	197.20 ±5.0 ^{e}	173.34 ± 5.0^{f}	196.49± 2.9^{b}		
Breast wob(g)	Male	184.91± 3.04^{a}	169.70 ±3.0^{b}	154.83± 3.0^{c}	169.81±1.8^{a}	148.78 ±1.2	5.77
	female	139.26 ± 3.04^{d}	137.60±3.0^{d}	106.4± 3.0^{e}	127.75 ± 1.8^{b}		
Back wt(g)	Male	154.41±3.07^{a}	125.89 ± 3.1^{b}	139.3 ±3.1^{c}	139.86±1.8^{a}	123.97 ±1.3	7.00
	female	112.85 ±3.07^{d}	106.45 ±3.1^{d}	104.9 ± 3.1^{d}	108.08 ±1.8^{b}		
Drumstick(g)	Male	180.93 ±2.8^{a}	168.00 ±2.8^{b}	140.68±2.8^{c}	163.20 ± 1.6^{a}	137.97± 1.1	5.67
	female	121.29 ± 2.8^{d}	117.93 ±2.8^{d}	99.01± 2.8^{e}	112.74 ±1.6 ^{b}		
Thigh wt(g)	Male	237.31 ±3.9^{a}	217.86 ±3.87^{b}	186.63 ±3.9^{c}	213.94 ±2.2 ^{a}	176.77±1.6	6.19
	female	161.23± 3.9^{d}	140.03 ±3.9^{e}	117.58± 3.9^{f}	139.61 ±2.2 ^{b}		
Wing wt(g)	Male	159.63± 2.2^{a}	146.03 ±2.2^{b}	125.89 ±2.2^{c}	143.85 ±1.3 ^{a}	122.57 ±0.9	5.09
	female	114.94 ±2.2^{d}	107.78 ±2.2^{d}	81.18 ± 2.2^{e}	101.30 ± 1.3^{b}		
Neck wt (g)	Male	75.63 ±1.4^{a}	63.96 ±1.4^{b}	55.13± 1.4 ^{c}	64.91 ±0.8^{a}	54.98 ±0.6	7.30
	female	47.36 ± 1.4^{d}	46.65±1.4^{de}	41.16± 1.4^{e}	45.06±0.8 ^{b}		
Shank wt(g)	Male	37.56 ± 1.2^{a}	29.20 ±1.2^{bc}	32.89±1.2^{ab}	33.22 ±0.7^{a}	27.63 ± 0.5	12.0
	female	20.03± 1.2^{e}	20.91 ±1.2^{de}	25.21± 1.2^{cd}	22.05 ±0.7^{b}		

Ls means with different superscripts are significantly different ($p<0.05$)

Total under the last column indicates effect of sex on carcass traits.

N = Total number of matured chickens used for carcass evaluation and n = number of chickens used per ecotype.

Table 46 (Continued)

Carcass traits		Agro-ecological zones					
	Sex	Lowland (n=16)	Midland (n=16)	Highland (n=16)	Total	Overall (N=48)	CV
Skin weight(g)	Male	92.80± 4.1^{ab}	81.74 ±4.1^{bc}	109.14± 4.1^{a}	94.56 ±2.3 ^{a}	83.38±1.7	13.74
	female	79.43± 4.1^{bcd}	74.11 ±4.1^{cd}	63.05± 4.1^{d}	72.20 ±2.3^{b}		
Paw weight (g)	Male	54.29 ±1.7^{a}	42.90±1.7^{b}	32.53 ±1.7^{c}	43.24 ±1.0^{a}	33.2± 0.7	14.65
	female	24.45 ±1.7^{de}	27.66±1.7^{cd}	17.41± 1.7^{e}	23.17 ±1.0^{b}		
Edible giblets							
Liver wt(g)	Male	29.13 ± 0.8^{a}	27.76 ±0.8^{a}	21.83± 0.8^{b}	26.24 ±0.5^{a}	26.63 ±0.3	8.76
	female	27.03 ±0.8^{a}	27.60 ±0.8^{a}	26.47 ± 0.8^{a}	27.03 ±0.5^{a}		
Gizzardwt(g)	Male	37.25 ±1.2^{a}	33.95±1.2^{ab}	20.65± 1.2^{c}	30.62 ± 0.7^{b}	32.21± 0.5	10.69
	female	38.33 ±1.2^{a}	33.64 ±1.2^{ab}	29.44± 1.2^{b}	33.80 ± 0.7^{a}		
Heart wt(g)	Male	9.66 ± 0.3^{a}	9.95 ±0.3^{a}	9.76± 0.3^{a}	9.79 ±0.2^{a}	8.39 ±0.1	10.17
	female	7.81 ±0.3^{b}	7.41 ±0.3^{b}	5.74 ± 0.3^{c}	6.99 ±0.2^{b}		

Ls means with different superscripts are significantly different ($p<0.05$)

Breast wb = weight of breast with bone, and Breast wob = Weight of breast without bone

Total under the last column indicates effect of sex on carcass traits.

N = Total number of matured chickens used for carcass evaluation and n= number of chickens used per ecotype.

4.8. Multivariate Analysis

4.8.1. Principal component analysis (PCA)

PCA is a dimension reduction procedure or data compression method which summarizes the data with a smaller number of variables losing as little information as possible. It is a mathematical procedure that transforms a larger number of possibly correlated variables in to a smaller number of uncorrelated variables called principal components. Principal components are correlated with original variables but uncorrelated with each other. The principal components are linear combinations of the original variables weighted by their contributions to explaining the variance in a particular orthogonal dimension.

4.8.1.1. Principal component analysis for local male chicken ecotypes

The result of the principal component analysis of male chicken ecotypes revealed that four principal components are extracted and retained based on the Eigen value - one criterion (Kaiser criterion) which states that any component with an Eigen value greater than one should be retained and interpreted (SAS, 2008). The first principal component explains about 42.4% of the total observed variation (Eigen value = 8.90), the second component (PC2) contributed to 16.97% of the observed variation in morphometric traits (Eigen value = 3.56), the third component accounted for 9.97% of the total variation (Eigen vale = 2.03) and the fourth component accounted for 5.24% of the total variations in the quantitative traits of the three male chicken ecotypes (Eigen value = 1.10). The Eigen values allowed to retain four principal components that provided a good summary of the data and explaining about 74.26% of the total morphometric traits' variability in the male chicken ecotypes of the zone (Table 47).

The analysis of Eigen vectors (loadings) of the principal components indicated that Principal component (PC1) has high loadings on shank length, comb width, earlobe length, earlobe width, wattle length, wattle width, beak length, spur length and wingspan of the male chicken ecotypes.

Therefore, PC1 is mostly considered as a measure of the variations in shank length, comb width, earlobes length, earlobe width, wattle length, wattle width, spur length and wingspan among the three male chicken ecotypes.

The variables most associated with principal component (PC2) were body length, body weight, comb length, comb index and neck and it is mainly served as the determinant factor for the variability of these traits among the male chicken ecotypes. In the same way, PC3 had higher loadings on skull length, skull width and skull index and it is mainly a measure of variability of skull traits of male chicken ecotypes while PC4 is highly correlated with earlobe index, wattle index, beak width and beak index and serve as a center measure of the variability of these traits among male chicken ecotypes of the zone.

Table 47: Eigen vectors and Eigen values of the four retained principal components for the 21 quantitative traits of local male chicken ecotypes in western Tigray

	Eigen vectors				
Traits	Prin1	Prin2	Prin3	Prin4	Communality
Body length	0.24	0.28	0.15	0.04	0.16
Body weight	0.22	0.27	-0.01	-0.10	0.14
Shank length	0.28	0.18	0.07	-0.13	0.13
Comb length	0.22	0.30	0.14	-0.07	0.17
Comb width	0.30	-0.09	0.01	-0.03	0.10
Comb index	-0.12	0.39	0.13	-0.04	0.19
Earlobe length	0.27	-0.17	0.08	0.12	0.12
Earlobe width	0.27	-0.23	-0.01	-0.10	0.14
Earlobe index	-0.16	0.23	0.11	0.28	0.17
Wattle length	0.28	-0.10	-0.11	-0.15	0.12
Wattle width	0.26	-0.09	-0.24	-0.23	0.19
Wattle index	-0.06	0.09	-0.05	0.63	0.40
Skull length	0.03	0.19	-0.52	-0.05	0.31
Skull width	0.10	0.19	-0.59	0.06	0.40
Skull index	-0.09	-0.09	0.40	-0.26	0.24
Neck length	-0.01	0.46	0.07	-0.02	0.22
Beak length	0.22	0.17	0.17	0.06	0.11
Beak width	0.26	-0.06	0.09	0.36	0.21
Beak index	-0.20	0.18	-0.01	-0.41	0.24
Spur length	0.29	-0.13	0.09	0.10	0.12
Wing span	0.29	0.18	0.10	0.01	0.13
Eigen value	8.90	3.56	2.03	1.10	
Difference	5.34	1.54	0.92		
% of total variance	42.4	16.97	9.64	5.24	
Cumulative (%)	42.4	59.37	69.01	74.26	

4.8.1.2. Principal component analysis for local female chicken ecotypes

Similar to male chicken ecotypes, the principal component analysis revealed that seven meaningful principal components are extracted and retained based on the Kaiser criterion which summarize the variability among the three local female chicken ecotypes (Table 48). The first principal component (PC1) accounted for 20.01% of the observed variations (Eigen value = 4.20) which had higher loadings mainly on earlobe width, earlobe length, wattle width and wattle index. The second principal components (PC2) explained about 12.69 % of the observed morphometric variation (Eigen value = 2.67) and has higher loadings on skull length, skull width, skull index and wing span which mainly express the variations of these traits among the female ecotypes. Moreover, PC3 accounted about 9.23% of the total variation (Eigen value =1.94) mainly on body length and neck length. PC4 also explained 8.94% of the observed variation in morphometric traits (Eigen value = 1.88) mainly on comb index, beak index and beak width. PC5 contributed to 8.36% of the total observed morphometric variations (Eigen value = 1.76) primarily on comb width and earlobe index. PC6 explained about 5.47% of the total variation (Eigen value = 1.15) mostly on body length and comb length while PC7 accounted for 5.05% of the total variability (Eigen value = 1.06) in the quantitative traits chiefly on shank length ,wattle length, beak length and spur length of the female chicken ecotypes.

Overall, the analysis of Eigen values indicated that the retained seven principal components provide a good summary of the data and explaining about 69.77% of the total morphometric traits' variability in the female chicken ecotypes of the area. The retained principal components for chicken sex ecotypes could aid in evaluating native chickens for breeding and selection purposes (Pinto *et al*., 2006; Yakubu *et al*., 2009). Since the correlation between principal components is zero, the selection of animals for any principal component will not cause correlated response in terms of other principal components (Pinto *et al*., 2006). Moreover, Yakubu *et al*. (2009) confirmed that the use of independent orthogonal indices (principal components) was more appropriate than the use of the original interrelated linear type traits for predicting the body weight of chicken.

This is because multicollinearity of two or more interdependent original body measurements could lead to unstable regression coefficients, hence erroneous inferences. In Nigeria, Yakubu *et al*. (2009) found that three principal components for Normal feathered chickens (PC1 (73.94%, PC2 (8.57%) and PC3 (5.33%) , necked neck chickens (PC1 (77.66%), PC2 (7.45%) and PC3 (5.49%) and frizzled chickens (PC1 (74.68%), PC2 (8.94% and PC3 (5.58%) and predicted body weights of the Nigerian chicks using these retained components and were more preferable for selecting animals for optimal balance.

This result was in agreement with the reports of Egena *et al*. (2014) and Adedibu *et al*. (2014) who reported that the first two retained principal components explained the highest variation (66.4% and 53.10% of the total variability, respectively) prevailing among indigenous Nigerian chicken populations. Adekoya *et al*. (2013) also reported that the first three extracted principal components provided a good summery and explained 68.201% of the total variations in the morphometric traits of five Nigerian indigenous chicken types (Frizzle feathers, Rose comb, necked neck, featherless wing and wild type). Likewise, Udeh & Ogbu (2011) reported that two, three and three principal component extracted in Arbor Acre, Morshal and Ross broiler strains of Nigerian chickens accounting 65%, 74.76% and 70% of the total variance respectively the three broiler strains. In New Zealand, Yakubu & Ayoade (2009) also reported that two principal components accounting for 90.27% of the total variation among domestic rabbits, and the first PCA1 termed as general size as it had its loadings for body length, heart girth and thigh circumference and explained 74.98% of the variance while PCA2 primarily determined from Ear length and contributed to 15.29% of the generalized variance among 103 New Zealand cross bred domestic rabbits. Udeh & Ogbu (2011) and Egena *et al.* (2014) confirmed that the retained principal components could be used as selection criteria for improving body weight or meatiness in broilers and used for predicting live weight and carcass weight of broilers.

In parallel to this, Yakubu *et al*. (2011) also pinpointed that the information from extracted principal components could aid for management, conservation and future selection and breeding programmes of Nigerian ducks. Udeh (2013) also identified that the principal component based prediction model is more reliable than the interdependent based models for prediction of body weight of Nigerian rabbits because it eliminates multicollinearity which be present of interdependent variables are combined in a multiple regression model.

Table 48: Eigenvectors and Eigen values of the Correlation Matrix for 21 morphometric traits of local female chicken ecotypes in western Tigray

			Eigen vectors					
Traits	Prin1	Prin2	Prin3	Prin4	Prin5	Prin 6	Prin 7	Communality
Body Le	-0.12	0.27	-0.05	0.14	0.09	0.41	-0.11	0.30
Body wt	0.03	0.08	0.39	0.09	0.04	-0.13	0.19	0.22
Shank le	0.16	0.21	0.26	-0.16	-0.01	-0.15	0.35	0.31
Comb le	0.24	-0.12	0.30	0.35	-0.06	0.38	0.06	0.43
Comb wd	-0.01	-0.03	0.21	-0.23	0.45	0.04	-0.19	0.34
Comb ix	0.22	-0.11	0.16	0.43	-0.33	0.32	0.17	0.52
Earlobe le	0.32	-0.21	-0.12	-0.01	-0.18	-0.27	-0.12	0.28
Earlobe wd	0.37	-0.25	-0.17	0.10	0.07	-0.19	0.01	0.28
Earlobe ix	-0.24	0.15	0.13	-0.15	-0.27	0.025	-0.14	0.21
Wattle le	0.25	0.12	0.36	-0.05	0.24	0.09	-0.37	0.41
Wattle wd	0.36	0.13	0.26	-0.04	0.13	-0.06	-0.34	0.35
Wattle ix	-0.32	-0.07	0.04	0.02	0.10	0.20	0.11	0.17
Skull le	0.15	0.33	-0.32	0.11	0.20	0.11	0.04	0.30
Skull wd	0.17	0.44	-0.29	0.21	0.05	-0.04	-0.07	0.36
Skull ix	-0.10	-0.34	0.17	-0.22	0.17	0.19	0.18	0.30
Neck le	-0.21	0.22	0.27	0.03	-0.21	-0.11	-0.05	0.23
Beak le	0.20	0.17	-0.09	-0.21	0.28	0.21	0.50	0.49
Beak wd	0.24	0.08	-0.10	-0.48	-0.22	0.33	0.08	0.47
Beak ix	-0.18	0.04	0.08	0.40	0.40	-0.25	0.22	0.47
Spur le	0.17	0.07	0.13	-0.10	-0.10	-0.30	0.34	0.28
Wing n	-0.04	0.40	0.17	-0.04	-0.25	-0.10	0.07	0.27
Eigen value	4.20	2.67	1.94	1.88	1.76	1.15	1.06	
Difference	1.54	0.73	0.06	0.12	0.61	0.09		
%of total variance	20.01	12.69	9.23	8.94	8.36	5.47	5.05	
Cumulative (%)	20.01	32.7	41.93	50.88	59.24	64.71	69.77	

NB: Body Le = body length; body wt = body weight; shank le = shank length; comb le = comb length; comb wd = comb width; combix = comb index; earlobe le = earlobe length, earlobe wd = earlobe width; earlobe ix = earlobe index; wattle le = wattle length; wattle wd = wattle width; wattle ix = wattle index skull le = skull length; skull wd = skull width; skull ix = skull index; neck le = neck length; beak le = beak length ; beak wd = beak width ; beak ix = beak index; spur le = spur length and wing n = wing length.

4.8.2. Canonical discriminant and step wise discriminant analysis

4.8.2.1. Canonical discriminant and step wise discriminant analysis for female chicken ecotypes

The result of the stepwise discriminant analysis for females indicated that the variables (Earlobe Length, wing span, skull length, shank length, earlobe width, neck length, body length, beak index, beak length, wattle index, body weight, earlobe index, comb index, wattle length, wattle width and skull index) are found to have potential discriminatory power for differentiating the three female chicken ecotypes. However, the most important variables for discriminating among the female ecotypes were the Earlobe length with the partial R^2 of 73.07% closely followed by wingspan, skull length, shank length, earlobe width, neck length and body length with partial R^2 of 40.75%, 27.94%, 20.97%, 16.71%, 5.48% and 4.93%, respectively showing the importance of earlobe and wing span for discriminating /differentiating the three female chicken ecotypes (Table 49).

Moreover, the canonical discriminant analysis of the female chicken ecotypes with twenty one (21) original quantitative traits revealed that two canonical variables are extracted where the first canonical variable (CAN1) or fisher linear discriminant function explained 63.58% of the total variation which can be considered reasonable and the second canonical variable (CAN2) explained 36.42% of the total variation, the two canonical variables extracted explained 100% of the total variations among the female chicken ecotypes. This enhances evaluation of animals with a reduced numbers of variables in an easy way because it is very difficult to weigh adequately each original trait in general index (Rosario *et al*., 2008).

The canonical discriminant analysis also showed that how each original variable aligned to each two canonical variables and weighing each original trait according to its contributions to the formation of each canonical variable. Body length, body weight, earlobe length, earlobe width, earlobe index, skull width and beak length had relatively higher weighing in extracting CAN1 while shank length, comb length, comb width, comb index, wattle length, wattle width, wattle index, skull length , skull index, neck length, beak width, beak index, spur length and wing span were highly loaded in Canonical variable two (CAN2). Canonical loading /weighing / measures the simple linear correlation between original independent variables and the dependent canonical variables and it reflects the variance that the observed variables shares with the canonical variates and interpreted as its relative contribution to each canonical variate function (Cruz-Castillo *et al*., 1994).

CAN 1 had high discriminating power than CAN2 because CAN1 axis show higher distinction and disposition of variates among the female ecotypes than CAN2, indicating that body length, body weight, earlobe length, earlobe width, earlobe index, skull width and beak length weighing higher in CAN 1 can serve as the most discriminating variables in discriminating/distinguishing among the female chicken ecotypes. Each canonical variable are linear combination of the independent original variables and are orthogonal to each other. The canonical discriminant analysis also measures the strength of the overall relationships between the linear composites of the predictors (canonical variables) and criterion variables (ecotypes). The significant canonical correlation among the female chicken ecotypes and the first canonical variables (rc = 0.905) and the ecotypes and the second canonical variables (rc = 0.849), indicate that the canonical variate explain the differentiation of the female chicken ecotypes, though the first canonical variable was more powerful than the second Canonical variable in discriminating the female ecotypes.

Table 49: Summary of step wise selection of traits through the STEPDISC Procedure for female chicken ecotype

Step	traits	Partial R2	F Value	Pr > F	Wilks'ʎ	Pr <ʎ	ASCC	Pr>ASCC
1	Earlobe Length	0.731	554.93	<.0001	0.26928	<.0001	0.36536	<.0001
2	Wing Span	0.408	140.31	<.0001	0.15955	<.0001	0.56632	<.0001
3	Skull Length	0.279	78.90	<.0001	0.11497	<.0001	0.65049	<.0001
4	Shank Length	0.210	53.86	<.0001	0.09086	<.0001	0.69596	<.0001
5	Earlobe Width	0.167	40.64	<.0001	0.07568	<.0001	0.71864	<.0001
6	Neck Length	0.055	11.71	<.0001	0.07153	<.0001	0.72691	<.0001
7	Body Length	0.049	10.45	<.0001	0.068	<.0001	0.73274	<.0001
8	Beak Index	0.045	9.52	<.0001	0.06493	<.0001	0.73981	<.0001
9	Beak Length	0.043	8.99	0.0002	0.06214	<.0001	0.74441	<.0001
10	Wattle Index	0.034	7.03	0.001	0.06003	<.0001	0.74909	<.0001
11	Body Weight	0.029	6.04	0.0026	0.05827	<.0001	0.7522	<.0001
12	Earlobe Index	0.024	4.98	0.0073	0.05684	<.0001	0.75464	<.0001
13	Comb Index	0.018	3.62	0.0276	0.05583	<.0001	0.75726	<.0001
14	Wattle Length	0.013	2.66	0.071	0.05508	<.0001	0.7586	<.0001
15	Wattle Width	0.024	4.83	0.0084	0.05377	<.0001	0.76196	<.0001
16	Skull Width	0.012	2.36	0.0961	0.05329	<.0001	0.76275	<.0001

All the variables in the table above are found to have potential discriminatory power. These variables are used to develop discrimination models in both the CANDISC and DISCRIM procedure.

Table 50: Classification summary for Local chicken ecotypes of Western Tigray

	Female chicken ecotypes			
From	Highland	Lowland	Midland	total
Highland	103(95.37%)	5(4.63%)	0	108(100%)
Lowland	3(1.83%)	161(98.17%)	0	164(100%)
Midland	0	3(2.14)	137(97.86%)	140(100%)
Total	106(25.73%)	169(41.02%)	137(33.25%)	412(100%)
priors	26.2%	39.8%	34%	
= 97.3% of original female chicken ecotypes are correctly classified with error rates of 2.7%				
	Male chicken ecotypes			
	Highland	Lowland	Midland	total
Highland	92(100%)	0	0	92(100%)
Lowland	0	146(100%)	0	146(100%)
Midland	0	0	120(100%)	120(100%)
Total	92(25.70%)	146(40.78%)	120(33.52%)	358(100%)
priors	25.70%	40.78%%	33.52%	
= 100% of original male chicken ecotypes are correctly classified with error rate of o%				

Diagonal of classification table indicate correctly classified numbers& percentages / each group.

Table 51: Proximity matrix or Pair wise generalized squared distance to local chicken ecotypes

From	Female			From	Male		
Ecotype	highland	lowland	midland		highland	lowland	midland
highland	0	19.32	30.17	highland	0	122.09	68.65
lowland	19.32	0	17.35	lowland	122.09	0	105.85
midland	30.17	17.35	0	midland	68.65	105.85	0

Table 52: Total –sample standardized Canonical Coefficients, Canonical correlations, class means on canonical variables and total variation explained by each variate of the local chicken ecotypes

Canonical correlations and total variation explained by each				
	Female chicken ecotypes		Male chicken ecotypes	
Variance explained	CAN 1	CAN2	CAN 1	CAN2
Variance (no)	4.52	2.59	23.26	9.94
Variance (%)	63.58	36.42	70.06	29.94
F value	63.86	50.44	243.91	166.97
Pr>F	<.0001	<.0001	<.0001	<.0001
Adjusted Canonical correlation	0.905	0.849	0.979	0.953
Total –sample standardized Canonical Coefficients				
Traits	CAN 1	CAN2	CAN 1	CAN2
Body length	-0.30	-0.06	1.18	-0.68
Body weight	-0.17	-0.07	-0.03	-0.48
Shank length	0.09	0.66	0.62	-0.22
Comb length	-0.19	-2.11	0.77	-0.09
Comb width	0.06	1.38	-0.07	-0.33
Comb index	0.13	2.48	-0.49	-0.73
Earlobe length	0.79	0.21	0.54	0.79
Earlobe width	1.60	-0.01	0. 50	0.46
Earlobe index	0.56	0.09	0.18	-0.07
Wattle length	-0.35	-0.69	-0.13	0.56
Wattle width	0.29	0.84	0.26	0.26
Wattle index	-0.03	0.18	-0.06	0.18
Skull length	-0.18	-0.79	-0.91	0.19
Skull width	0.28	-0.08	0.25	-0.29
Skull index	0.10	-0.11	0.16	-0.14
Neck length	-0.21	0.36	-0.04	-0.98
Beak length	-0.30	0.01	0.30	-0.16
Beak width	0.03	0.18	0.30	0.05
Beak index	-0.06	-0.09	-0.02	-0.15
Spur length	0.05	-0.08	0.67	0.54
Wing span	-0.08	1.08	0.95	-0.67
Class Means on Canonical Variables				
	Female chicken ecotypes		Male chicken ecotypes	
	CAN1	CAN2	CAN1	CAN2
highland	2.93	-1.52	-4.19	4.58
lowland	0.25	1.96	5.78	0.11
midland	-2.55	-1.12	-3.83	-3.65

The adjusted canonical correlation analysis indicated that the first canonical correlation is the greatest possible multiple correlation with the classes that can be achieved by using a linear combination of the quantitative variables. The first canonical correlation with male chicken and with female chicken ecotypes was (0.979172) and (0.90481), respectively (Table 52).

In the female chicken ecotypes, the first canonical variable, *Can1,* shows that the linear combination of the centered variables *Can1* = -0.30 x body length + -0.17 x body weight +0.086699 x shank length + -0.19 x comb length + 0.06 x comb width + 0.13x comb index +----- (-0.08) x Wing span and the second canonical correlation (CAN2) = -0.06 x body length + -0.07 x body weight + 0.66 x shank length +--- (1.08) x wing span separate the female chicken ecotypes most effectively. Likewise, in male chicken ecotypes, CAN1= 1.18023 x body length + -0.03X body weight + 0.62 x shank length + 0.77 x comb length **+** -0.07 x comb width + -0.49 x comb index +-----+ (0.95) x wing span and CAN 2**=** -0.68 x body length + -0.48 x body weight **+** -0.22 x shank length + -0.09 x comb length + **-**0.33 x comb width + -0.73 x comb index **+----+** (-0.67) x wing span which explained 70.06% and 29.94% of the total morphometric variations among the male chicken ecotypes and differentiated the male chicken ecotypes more efficiently.

4.8.2.2. Canonical discriminant and step wise discriminant analysis for male chicken ecotypes

The result of stepwise discriminant analysis indicated that 16(wing span, neck length, earlobe length, spur length, body length, skull length, shank length, earlobe index, comb length, wattle length, comb index, beak width, body weight, beak index, wattle index and wattle width) out of 21 quantitative traits are found to have a potential discriminating power for differentiating the three male chicken ecotypes. However, the most important discriminating traits wing span with partial R^2 of 85.74% closely followed by neck length, earlobe length, spur length, body length, skull length, shank length, earlobe index, comb length and wattle length with partial R^2 of 69.94%, 47.17%, 26.26%, 23.42%, 23.41%, 16.40%, 13.98%, 13.18 % and 12.92%, respectively indicating that the importance of wing span, neck length, earlobe length, spur length, body length and skull length for differentiating of the male chicken ecotypes (Table 53).

Furthermore, the canonical discriminant analysis of 21 quantitative traits of male chicken ecotypes showed that two significant canonical variables are extracted to summarize the total morphometric variability among the male ecotypes. The first canonical variable or fisher linear discriminant function explained 70.06 % of the total variations which can be considered reasonable while the second canonical variable (CAN2) accounted for 29.94% of the total observed variations morphometric variations among the male chicken ecotypes, the two canonical variables extracted together explained 100% of the total morphometric variations among the male chicken ecotypes.

The Total –sample standardized Canonical Coefficients of canonical discriminant analysis of the male chicken ecotypes revealed that how each original variable aligned to each two canonical variables and weighing each original trait according to its contributions to the formation of each canonical variable extracted. Body length, shank length, comb length, earlobe width, earlobe index, wattle width, skull length, skull index, beak length, beak width, spur length and wing span had relatively superior weighing in extracting CAN1 whereas body weight ,comb width, comb index, earlobe length ,wattle length ,wattle index, skull width ,neck length and beak index were highly loaded in canonical variable (CAN 2). CAN1 had higher discriminating power than CAN2 since CAN1 had a comparative advantage of 134% over the CAN2 for explanations of the morphometric variability existing among the male chicken ecotypes. Hence, this indicates that Body length, shank length, comb length, earlobe width, earlobe index, wattle width, skull length, skull index, beak length, beak width, spur length and wing span can serve as most important discriminating variables for maximizing the separation among male chicken ecotypes of Western Tigray.

Moreover, the canonical discriminant analysis also measures the strength of the overall relationship between the predicators (canonical variables) and the criterion variables (ecotypes). The significant canonical correlation among the male chicken ecotypes and the first canonical variables (rc = 0.979172) and the ecotypes and the second canonical variables (rc = 0.953194), indicate that the canonical variate explain the differentiation of the male chicken ecotypes, though the first canonical variable was more powerful than the second Canonical variable in discriminating the male ecotypes.

Similarly, Ogah *et al*. (2011) reported that body weight, body width and body height with partial R^2 of 27.4%, 23.6% and 19.9%, respectively were the most important discriminating traits among three Nigerian Muscovy duck ecotypes. Furthermore, Adedibu *et al*. (2014) also reported that feather, earlobe and beak colors, age, body and neck lengths were found to be responsible for most of the variations among populations of helmeted guinea fowl of Nigerian chickens. Eskindir *et al*. (2014) also reported that shank length, body length, comb width, body weight, wing span and comb height were found to have more discriminating power causing morphological variations between Horro and Jarso chicken ecotypes of Ethiopia. In Jordan, Al-Atiyat (2009) also found that average live weight and carcass weight were the most important traits to discriminate among the chicken populations of Jordan. Moreover, the findings of Yakubu *et al*. (2011) revealed that foot length, neck length, thigh, thigh circumferences and body length were more discriminating traits in explaining morphological variability between ducks from the two zones of Nigerian ducks.

Table 53: Summary of step wise selection of traits through the STEPDISC Procedure for male chicken ecotypes

Step	Traits	Partial R2	F Value	Pr > F	Wilks'ʎ	Pr <ʎ	ASCC	Pr >ASCC
1	Wing span	0.8574	1067.53	<.0001	0.14257	<.0001	0.42872	<.0001
2	Neck length	0.6994	411.9	<.0001	0.04285	<.0001	0.77766	<.0001
3	Earlobe length	0.4717	157.61	<.0001	0.02264	<.0001	0.84312	<.0001
4	Spur length	0.2626	62.69	<.0001	0.01669	<.0001	0.86148	<.0001
5	Body length	0.2342	53.69	<.0001	0.01278	<.0001	0.88086	<.0001
6	Skull length	0.2341	53.49	<.0001	0.00979	<.0001	0.89261	<.0001
7	Shank length	0.164	34.22	<.0001	0.00818	<.0001	0.89868	<.0001
8	Earlobe index	0.1398	28.28	<.0001	0.00704	<.0001	0.90754	<.0001
9	Comb length	0.1318	26.34	<.0001	0.00611	<.0001	0.9138	<.0001
10	Wattle length	0.1292	25.66	<.0001	0.00532	<.0001	0.92162	<.0001
11	comb index	0.0742	13.83	<.0001	0.00493	<.0001	0.92369	<.0001
12	Beak width	0.0642	11.79	<.0001	0.00461	<.0001	0.92603	<.0001
13	Body weight	0.0643	11.79	<.0001	0.00431	<.0001	0.92935	<.0001
14	Beak index	0.0532	9.62	<.0001	0.00409	<.0001	0.93094	<.0001
15	Wattle index	0.0299	5.25	0.0057	0.00396	<.0001	0.93213	<.0001
16	Wattle width	0.0244	4.25	0.015	0.00387	<.0001	0.93282	<.0001

ASCC=Average Squared Canonical Correlation. All the variables in the above table are found to have potential discriminatory power. These variables are used to develop discrimination models in both the CANDISC and DISCRIM procedure

4.8.3. Cluster analysis

4.8.3.1. Cluster analysis for female chicken ecotypes

The Dendogram in cluster analysis of female chicken ecotypes based on twenty one (21) traits grouped in to three distinct female chicken ecotypes (Fig 2). The discriminant analysis also showed that the three female chicken ecotypes were characterized as three distinct clusters based on the estimated of Mahalanobis distance among three female populations (Table 51). The discriminating function results revealed that the ecotypes were properly classified as three distinct groups with a total classification success rate of the discriminant function was 97.3%. Moreover, the result indicated that lowland female chicken ecotypes were the more correctly classified (98.17%) followed by midland chicken ecotypes (97. 86%) while the highland chicken ecotypes were the least correctly classified (95.37%). In the same way, the distance between all pair wise chicken ecotypes were highly significant ($p<0.001$). The greatest distance value was between highland and midland female chicken ecotypes (30.17) whereas the lowest distance value was between midland and lowland chicken ecotypes (17.35). The lowest Mahalanobis distance between lowland and midland female chicken ecotypes (17.35), and between highland and lowland chicken ecotypes (19.32) is an indication of gene flow from either of highland and /or midland to lowland chicken ecotypes. This could be due to local chicken products (live chicken and eggs) from both highland and midland are always collected and transported either by local chicken producers and/or local chicken traders to lowland agro-ecology of the zone during every time specifically Ethiopian religious festivities and Ethiopian new year as the price of chicken products in both (midland and highland) is much lower (cheaper) than from the lowland agro-ecology. This also might be due to seasonal movement of farmers together with their domestic animals particularly oxen, donkey and chickens from both agro-ecologies to lowland agro-ecology every rainy season to cultivate either their own or rented land as there is scarcity of cultivated land in both agro-ecologies (midland and highland).

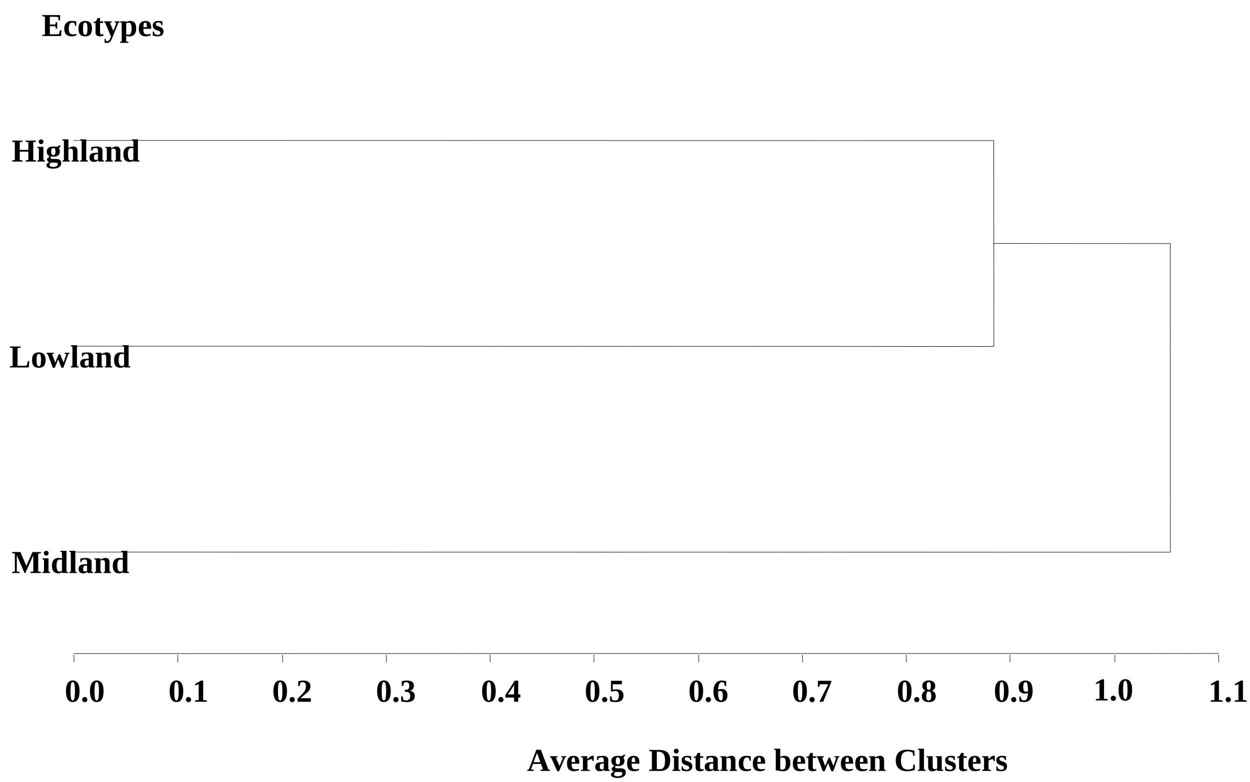


Figure 2: Dendogram for 412 adult female chicken ecotypes by average LINKAGE cluster

4.8.3.2. Cluster analysis for male chicken ecotypes

Similar to female chicken ecotypes, the Dendogram of the cluster analysis indicated that the three male chicken ecotypes were classified as three different clusters based on twenty one (21) morphometric traits (Fig 2). The discriminant analysis of male chicken ecotypes revealed that 358 male chickens were categorized in to three distinct groups based on the Mahalanobis distance estimated among three male chicken populations (Table 51). The result of discriminant analysis also showed that the male chicken ecotypes were very properly classified as three distinct groups with a total classification success rate of the discriminant function was 100%. Furthermore, the result also confirmed that male chicken ecotypes were correctly classified in to three different categories using variations in agro-ecologies as classification variable with 100% of original male chicken ecotypes are correctly classified with error rate of o%. The distance value between highland and lowland male chicken ecotypes was 122.09 which was slightly higher than from the distance between lowland and midland chicken ecotypes (105.85) while the relatively least distance was observed between highland and midland ecotypes (68.65) though the distance obtained between all male chicken populations were significant. This relatively low distance observed between midland and highland ecotypes is an indication of relatively high gene flow between the two chicken ecotypes. The probable reason for the order (distance) of chicken ecotypes in the Dendogram of male is different from female chicken ecotypes might be due to the probability of sampling highland cocks from the lowland male chicken population is less. Because most farmers keep one cock per their flock and more layers for breeding purpose and farmers usually prefer to sell or slaughter more males to females.

Generally, the overall percentage of correctly classified individual chickens in female sexes was 97.3% (the proportion of individual correctly classified in highland (95.37%), midland (97.86%) and lowland (98.17%) and in male sexes was 100% (the proportion of individual correctly classified in each group was also 100%) which was higher than 81.5% of correctly classified individual Nigerian Muscovy ducks (individually: rainforest (94.9%), dry (85.4%) and guinea savannah (71.9%) (Ogah *et al.*, 2011).

Moreover, Adekoya *et al*. (2013) also found that lower figures on overall correctly classified individual Nigerian chicken genotypes in to three clusters was 56% and the proportion of individuals correctly classified in wild type (78.6%),then necked neck (63.6%) and feathered chickens (60%). Gwaza *et al*. (2013) had also reported that the overall correctly classified Nigerian chicken ecotypes in guinea savannah was 37.72% and the proportion of individuals correctly classified as group one (42.8%), group two (35.2%), group three (59.4%) and group four (36.4).

On the other hand, the distance obtained in both ecotypes sexes in this study was much higher from the research reports of morphometric variation evaluation of two Nigerian Muscovy duck ecotypes revealed that the Mahalanobis distance between Guinea Savannah and Rainforest zones of Muscovy ducks was 3.39 (Yakubu *et al*. ,2011). Ogah (2013) also reported that very lower distance between normal feathered and necked neck (3.371), necked neck and frizzled (3.757) and normal feathered and frizzled chickens (4.620) when studying diversity among three Nigerian chicken genotypes using canonical discriminant analysis of 8 parameters. Similarly, the distance obtained among all chicken ecotypes of female sexes was lower than what Ogah *et al*. (2011) obtained between three Nigerian Muscovy duck ecotypes but distance between male ecotypes was higher than from the findings of Ogah *et al*. (2011) revealed that distance between Guinea and Dry ducks (54.803), Guinea and Rainforest (34.120) and rainforest and dry (35.435) in assessment of genetic variation among three Muscovy ducks based on 20 morphometric traits using canonical discriminant analysis. However, the distance between both ecotype sexes was lower than from research findings of Al-Atiyat (2009) when studying diversity of six-week old indigenous, commercial layers and broiler chickens (distance between broiler and indigenous (433.88), broiler and layers (429.8 7) and indigenous and layer (38.313)) using discriminate analysis of 20 performance traits in Jordan.

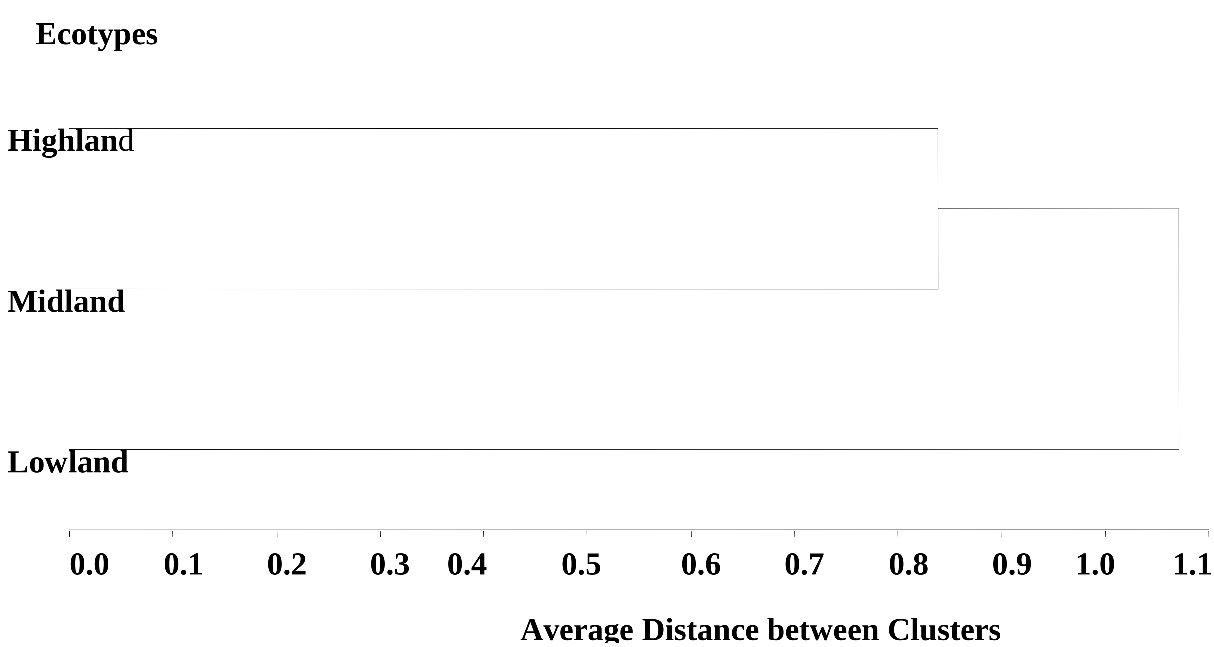


Figure 3: Dendogram for 358 adult male chicken ecotypes by average LINKAGE cluster

4.9. Opportunity of Village Chicken Production.

Feed access was outlined as an opportunity of village chicken production in the study area during both the Focused group discussion and individual interview of the survey. Because the zone as a whole and the lowland in particular is the Center of mechanized Agriculture investment area in Tigray region. Besides, there are several private organizations engaged in production and processing of cash crops particularly Sesame and cotton. Among these, Hiwot Mechanization Private Organization has engaged in mechanized production of sorghum, sesame and cotton, refining and exporting sesame and processing and extraction of edible oil from cotton seed. This indirectly increases the availability of cotton seed cake and sesame refining left over as protein supplementary feeds with affordable prices for chicken in particular and in general livestock producers in the area. Guna private organization is the second largest private organization engaging in refining and exporting refined sesame which eventually optimizes the availability of sesame refining left over as animal feeds. Warka Trading Private Company is also another company engaged in sesame and cotton production and refining sesame and exporting refined sesame. Moreover, Sesame Hauling Private Company is another fourth private company engaged in sesame production and refining sesame. All these increase the availability of concentrate supplementary feeds of livestock with affordable prices and will have pivotal role in the expansion of sustainable poultry production industry in the future.

In addition to these, all investors engaged in Agriculture have been producing sesame and sorghum in mechanized way and larger scale. They are selling sesame to either of Ethiopian Commodity Exchange Humera Branch, Guna private organization or Warka Trading Private Company whereas they sell sorghum to local market as staple food. This will create an opportunity for small scale village chicken producers to purchase sorghum with cheaper prices for both human food and chicken supplementary feeds.

Market access is also cited as another pronounced opportunity of village chicken production in the study area. Since the study area shares borders with Sudan in West and Eritrea in the North which increase the marketing opportunity for village chicken producers to sell their chicken products with better prices. This has played a pivotal role for encouraging farmers to produce more and to attract local and international investors to invest their capitals on intensive local chicken based poultry production industry. This will serve as a big opportunity for the growth/development of sustainable poultry production in the study area. However, exchange of livestock products in general and poultry products in particular across border should be carried under control otherwise it may cause genetic erosion or genetic depression of the existing indigenous chicken genetic resources.

Moreover, the lowland agro-ecology of the zone is the center of investment zone and in particular Kafta Humera is the center of Sesame investment zone. Due to this fact, different investors from different corners of Ethiopia as well as from Sudan, Eritrea, Nigeria and Senegal are engaging in different investment areas of the study area. Investors from Nigeria and Senegal are primarily engaging in trading while Ethiopian investors and investors from Eritrea and Sudan are mainly engaging in Agricultural investment especially mechanized sesame production. Around 500,000 daily laborers are required for weeding, harvesting and threshing of sesame, sorghum and cotton annually. Daily laborers from different corners of Ethiopia as well as from Sudan are flowing to this investment Zone every cropping season. Furthermore, the establishment of National Sugar Factory in Welkait (Mezega area) is also another opportunity for marketing access of chicken products. These serve as factors for the increment of poultry products demand and the price of eggs and live chickens relatively higher in the zone than in other areas of Tigray region. These encourage small scale farmers to improve and expand village chicken production.

Drinking water access for all human and livestocks as well as for irrigation is another opportunity for sustainable livestock productivity in the zone. Tekezze, Kazza and Bahireselam are the three main rivers used for all purposes.

Diversified agro- ecological zones of the study area is another opportunity for genetic improvement of indigenous chicken populations. Because diversified agro-ecological zones is an indicator for the existence of different livestock populations with diversified phenotypic performances and high genetic variability. As it creates a suitable environment for different livestock breeds and strains to adapt and perform differently in different agro-ecologies. This variability will serve as row material for genetic potential improvement of the indigenous chicken population through Selection and help to initiate breeding programme for preservation of chicken genetic resources.

Ease management of village chicken production in relation to large livestock is also considered as opportunity for the growth development of village chicken production. Indigenous chickens are reared with low inputs and managed by every family member from children to very old persons. Chickens are considered as poor man's bank/immediate source of income for any duties/ by small scale farmers in the study area because they have short generation interval in comparison to other livestock species. A man with a chicken is considered as a man who deposited money in a bank.

This result corroborated the findings of Melkamu & Wube (2013) in which market access (36%), credit service (28%), feed access (20%) and training and extension (16%) were the opportunities of village chicken production in Debsan Tikara kebele at Gonder Zuria woreda, North Gonder of Ethiopia.

4.10. Adaptability Traits and Some Important Characteristics of Local Chicken Ecotypes

The pooled analysis of both individual interview (Appendix table 7) and Focus group discussion indicated that lowland chicken ecotypes are highly adaptable /tolerant/ to extreme heat temperature whereas highland chicken ecotypes are less adaptable /tolerant to environments with high temperature. However, highland chicken ecotypes are highly tolerant to extreme cold while chicken ecotypes from lowland are less adaptable to extreme cold. Chicken ecotypes from midland are moderately adaptable to both environments with extreme temperature and cold. Moreover, chicken ecotypes from lowland agro-ecological zone have relatively higher drought tolerance than midland chicken ecotypes whereas highland chicken ecotypes have low drought tolerance. All chicken ecotypes have moderately basic temperament, stress and disease and parasites. Furthermore, the respondents and focus group discussion members replied that all of the three chicken ecotypes have the ability to escape from predators (flightiness). 100% of both midland and highland chicken ecotypes have excellent scavenging vigor. However, 75.6% and 24.4% of the lowland chicken ecotypes have excellent and very good scavenging vigor.

Overall, local chicken ecotypes are highly adaptive to low input production system because of the above adaptive attributes. This indicates that they are highly adaptable to wide range of environmental conditions and this enables them to develop acquire immunity that help them to be relatively productive with little inputs everywhere as compared to exotic breeds. This result is somewhat similar with the findings of Bogale (2008) revealed that 100% of female and 76% of male Fogera chickens had moderately tractable and highly adaptable to harsh environmental conditions like heat and swamp tolerance. Indigenous fowl populations are considered as gene reservoirs of genetic materials particularly for adaptive or hardiness genes for genetic studies, genetic improvement, preservation and conservation (Abdelqader *et al*., 2007; Adekoya *et al*., 2013). Nigussie *et al*. (2010b) also reported that 86%, 96%, 83% and 86% of the indigenous chickens were found to be superior to modern breeds (RIR) with respect to disease and stress tolerance, escape from predators, lower management required and excellent scavenging behavior, respectively in three districts (Farta, Horro and Sheka) of Ethiopia. Designing and implementation of environmentally friendly breeding and improved production programs (strategies) of local chicken ecotypes should incorporate their adaptive genetic merits in order to ensure food security of small scale farmers through sustainable utilization of indigenous chicken genetic resources.

5. SUMMARY AND CONCLUSIONS

The indigenous, exotic and crossbreed chicken flock size per household were 22.83±10.60, 0.96±1.76 and 1.57±2.19, respectively in the study area. This implies that the households may have a mix of chicken genotypes which in turn creates widen opportunity for unplanned /indiscriminate crossbreeding to be existed among the flock. Moreover, village chicken flocks scavenge together and interbreed among themselves in the study area and some breeding cocks are more dominant and aggressive than others. These situations will increase the chance of consecutive interbreeding among more related chickens which in turn increase the incidence of inbreeding. Therefore, farmers need to be encouraged to avoid mating of closely related individuals among their chicken flocks through keeping breeding cocks and exchanging them with other farmers located further than the scavenging distance (Rotational mating).

Sole women (28.6%) and sole men (28.6%) had greater and equal share of responsibilities with respect to chicken shelter construction among family members in the study area inspite of their responsibilities varied across the agro-ecological zones. However, both women and female children and sole women had the first and second responsibilities of offering feed and water, cleaning poultry house and selling chickens and eggs. Men had the highest share of responsibilities of purchasing drugs (79.7%) followed by women (16.6%). Similarly, women had the greatest share to decide on eggs for selling (97.4%), home consumption (98.7%), chicken selling (93.5%), purchase of eggs (98.7%) and purchase of chickens. On the other hand, decisions on chickens for home consumption (76.1%) and offering chicken product as a gift (76.4%) were accomplished by the common decision of men and women while men had the major decision role for purchasing drugs /treatment (70.6%) in the study area.

All of the respondents (100%) practiced supplementary feeding on top of scavenging. Sorghum, maize, sesame, tomato, onion, barley, and household food left over were main supplementary feeds in the study area. Farmers provided supplementary feeds to their chickens once / morning (98.7%), once/afternoon (69.6%) and once/evening (81.3%) mostly thrown on the ground (97.9%) for collective feeding (94.8%). There is an improvement in the perception of farmers towards proper feed supplementation of chickens improves chicken productivity and health as time goes through acquired knowledge from their experiences and extension services. Feed is a critical problem in both dry and wet season under village scavenging poultry production system that may necessitate persuading the farmers to practice strategic supplementation to increase meat and egg production thereby to attain food security. Likewise, of the total respondents, 59.5% of them constructed separate chicken house comprising of permanent (56.1%) and temporary or seasonal (3.4%) separate houses. Moreover, 57.7% of them practiced cleaning of chicken houses with a frequency of ranging from once/a day (66%) to none at all (2.1%). All of the respondents (100%) offered water for chickens of Adlib (70.9%), once/a day (7.5%) and twice /a day (21.6%) either from well, tap water or river. Waterers made from Plastic materials, stone, wood (*Hilab* or *Galibba*), metal (dish or *bredisti*), broken pieces of pot and gourd (*Kil*) were the commonly used materials for water provision of chickens in the study area. Besides, Farmers (86%) practiced washing of chicken waterers even if the frequency of washing waterers varied among agro-ecologies. This indicates that farmers seem to have good practices of keeping clean watering devices of chicken but inadequate for openly placed waterers and feeders because opened waterers are much more likely to be contaminated by dirt, soils, litter or chicken droppings. The water becomes dirty and eventually builds up of sticky materials within the waterers that provide a favorable environment for development of harmful bacteria, viruses and fungi that cause serious consequences for the health of flock and egg production. It is, therefore, highly recommendable to keep chicken waterers clean through cleaning water devices every time whenever water is provided for chickens. Moreover, waterers have always been placed in an open place which is accessible for cats, dogs, wild birds and large animals which may result in disease transmission from wild birds to chickens as well as from either dogs or cats to chickens. Thus, farmers should be strongly encouraged to minimize the risk of contamination of waterers by other animals and wild birds by placing chicken waterers and feeder in the coop/ run to reduce the risk of water and food contamination.

Disease (1^{st}) and (predators (2^{nd}) were the main pronounced constraints of poultry production. Among the disease, Newcastle disease (1^{st}), fowl salmonella (2^{nd}) and coccidiosis (3^{rd}), were the major economically important diseases that hinder the expansion of village chicken production in the study area. On the other hand, feed access, market access, drinking water access and diversified agro-ecological zones of the zone were the most imperative identified opportunities of village chicken production which open a room for sustainable local chicken productivity improvement in the study area.

Eggs and live chickens are the marketable chicken products. Almost all respondents (99.7%) had participated in selling of chicken products. Same village (64.2%), woreda market (3.3%) and both same village and woreda market (32.2%) are the marketing outlets of chicken products in the study area. Of the total respondents, 93.8% of them had faced marketing problems primarily poor infrastructure and lack of information (28.8%), poor infrastructure (22.4%) and lack of market place and infrastructure (15.6%). Plumage color (1^{st}), body weight (2^{nd}) and comb type (3^{rd}) were the major price determinants of live chicken while market site was the main determinant of egg prices.

Broody hens were the sole means of egg incubation and chick brooding in the study area. Plumage color, egg yield, body weight (size) and mothering ability were selection criteria used for choosing broody hens. Farmers (39.2%) selected eggs for incubation mainly based on egg type, egg age and season/month of laying. Eggs Laid at home was the predominant sources of incubation eggs in the study area. Few farmers (5.5%) practiced to wash eggs with cold water and warm water and cleaning with clothes or other materials prior to incubation in order to have cleaned eggs for incubation. Local chicken producers tried to create comfortable incubation environment through preparation of egg setting and bedding materials. June to February especially autumn were the most preferred months of the year to incubate eggs and to achieve best hatchability of eggs by broody hens while March to May was the worst months of the year for incubation and hatchability of eggs because of high environmental temperatures, prevalence of diseases and predators and shortage of green feeds to scavenge.
Environmental temperature, lack of proper laying nest and post handling were the critical causes of failure of egg hatchability in the study area. Almost all respondents (96.1%) were capable of checking fertility of eggs prior to incubation by visual examination, floating in water, shaking , cooking sample eggs, breaking sample eggs and weighing. All respondents (97.4%) attempt to increase egg production by stimulating broody hens to resume laying.

Hanging upside down, disturbing in the nest ,moving to neighbors ,tying both wings together, tying outside the original laying nest, tying plastic materials on legs and piercing of noise were the commonly practiced traditional methods of breaking broodiness in the study area. However, great emphasis should be to wards in selection of farmers with healthy flock when we want to break the brooding behavior of ours by moving to neighbors otherwise it may serve as sources of infection for our flocks.

Both controlled and uncontrolled mating systems are practiced but uncontrolled mating (96.4%) was commonly practiced mainly due to free scavenging production system. Culling poor productive (43.9%) retaining best cocks and layers for further breeding (36.9%), cull at early age (13.2%) and preventing mate (6%) were the major ways of matting control for improvement. Crossbreeding (10.4%), line breeding (86.2%), and both cross and line breeding (3.4%) were practiced to improve the egg productivity of local chickens. Sales for income (1^{st}), home consumption and ceremony (2^{nd}), ceremony (3^{rd}) and breeding /hatching ($4^{th)}$ were the main breeding objectives of local chicken producers. Plumage color (1^{st}), egg laid /clutch (2^{nd}) and comb type (3^{rd}) were the major traits of preference of local chicken producers. Egg laid/clutch (1^{st}), body weight (growth) (2^{nd}) and adaptations (3rd) were the major preferred traits to be improved through breeding in the study area.

Significant variations were detected among the local chicken ecotypes with respect to performance traits. Age at first egg laying, age of sexual maturity, hatchability, average weight of day old, one week, one and three months of chickens were highly significant among chicken ecotypes. Besides, the effective population size (Ne) and the rate of change of inbreeding coefficient (ΔF) of chicken flock was 1263.69 and 0.04%, respectively in the study area which indicated that the population is not at the risk of extinction and high genetic variabilities among chicken ecotypes.

The local chicken ecotypes in three agro-ecological zones had distinct physical variations for both quantitative and qualitative traits in the free scavenging management system. This may serve as an opportunity for improving the genetic potential of indigenous chickens through appropriate breeding methods such as selection. All Carcass traits except skin weight of local chicken in the age of 10-12 months were significantly different among the three chicken ecotypes. This opens way for genetic improvement of the carcass traits through selection among the local chicken ecotypes.

Four and seven retained principal components provide a good summary of the data and explaining about 74.26% and 69.77% of the total morphometric traits' variability in the male and female chicken ecotypes of the zone, respectively. Two significant canonical variables were extracted, CAN1 explained 63.58% and 70.06% of the total variation among the female and male chicken ecotypes, respectively and (CAN2) explained 36.42% and 29.94% of the total variation among the female and male chicken ecotypes, respectively. Wing span, neck length, earlobe length, spur length, body length ,skull length, with partial R^2 of 85.74%, 69.94%, 47.17%, 26.26%, 23.42% and 23.41%, respectively indicating the order of importance for differentiating of the male chicken ecotypes. In the same context, Earlobe length, wingspan, skull length and shank length with partial R^2 of 73.07%, 40.75%, 27.94% and 20.97% respectively were showing the order of their significance power for discriminating the three female chicken ecotypes.

By taking agro-ecology as class variable and the twenty one morphometric traits as predictors, the three male chicken ecotypes classified as three different clusters with a total classification success rate of the discriminant function was 100% and error rate of 0%. Female chicken ecotypes were also characterized as three distinct populations with a total classification success rate of the discriminant function was 97.3% and error rate of 2.7%. Finally, it could conclude that there are phenotypic variations among chicken flocks raised under different agro-ecological zones. Thus, the indigenous chickens of western zone of Tigray classified as lowland, midland and highland chicken ecotypes based on agro-ecology.

Recommendation

Based on the findings of the study, the following points are forwarded for further studies**:**

- ✓ On station performance evaluation of these three local chicken ecotypes.
- ✓ Assessment and documentation of traditional practices of poultry disease treatment as well as smoking practices of chicken parasites.
- ✓ Genetic characterization based on molecular assessment should be implemented to validate the detected phenotypic variations and evaluate the genetic diversity among and within the three chicken ecotypes.

It is highly recommended to ensure the present and future sustainable utilization, improvement and conservation of the detected phenotypic diversities/variations/ among the local chicken ecotypes. This is achieved by

- ✓ Designing and implementing agro-ecologically friendly and community based genetic and production improvement programmes which incorporate breeding objectives , trait preferences, local chicken adaptive genetic merits and consumer preferences in order to ensure food security of small scale farmers through sustainable utilization of indigenous chicken genetic resources.

Superior carcass performance of lowland chicken ecotypes together with the existence of greater marketing opportunities in the lowland agro-ecology can serve as important resources for lowland poultry farmers to obtain increased carcass production and maximum profit in the poultry industry. Thus, it is highly recommended that farmers should use chickens from lowland for better broiler meat production in the lowland.

Traditional breeding programs like clan mating and breeding out-and-out are the highly recommended strategies to improve the stock and maintain genetic diversity as well as to minimize the incidence of inbreeding at small-scale farmers with a small flock size (Craig *et al*., 2006).

Awareness creation should be given on the following management measures in a strengthen manner in order to improve poultry productivity and to ensure food security of chicken producers**:**

- ✓ How to maintain healthy flock (how to avoid means of disease transmissions and prevention techniques)
- ✓ Proper feeding and watering like how to avoid water born diseases (eg. Fowl cholera, Avain Influenza and others)
- ✓ How to construct proper chicken houses
- ✓ How to keep proper sanitation / cleaning / and disinfection of house, nests, waterers and feeders
- ✓ Dead birds or parts of dead birds should be burned or buried deep enough to avoid that dogs, cats and other animals dig them up and spread the diseases.
- ✓ How to prepare proper brooding nest or laying nest, egg selection, proper post handling storages, egg setting and bedding

The following chicken productivity impromvent inputs should be supplied by concerned bodies in a strengthen manner:

- ✓ Extension services with full packages for better improvement of poultry development strategy
- ✓ Veterinary drugs and vaccines with affordable prices throughout the year
- ✓ Market place for chicken products should be secured
- ✓ Improving Credit services for small scale farmers and
- ✓ Market-oriented chicken productivity improvement interventions like improved chicken breeds (RIR)

6. REFERENCES

Abdelqader, A., Wollny, C. B. A. & Gauly, M. 2007. Characterization of Local Chicken Production Systems and their Potential under Different Levels of Management Practice in Jordan. *Tropical Animal Health and Production,* **39**(**3**): 155–164.

Aberra, M. 2000. Comparative Studies on Performance and Physiological Responses of Ethiopian Indigenous (Angete Melata) Chickens and Their F1 Crosses to Long Term Heat Exposure. PhD Dissertation. Martin-Luther University, Halle -Wittenberg Germany, pp: 127.

Aberra, M., Zemene, W. & Yosef, T.2012.Assessment of the Prevailing handling and Quality of Eggs from Scavenging Indigenous Chickens Reared in Different Agro-ecological Zones of Ethiopia. *Research Journal of poultry Sciences,* **5(4-6**):64-70.

Aboe, P., Boa-Amponsem, K., Okantah, S., Dorward, P. & Bryant, M. 2006. Free-Range Village Chickens on the Accra Plains, Ghana: Their Contribution to Households. *Trop Anim Health Prod*, **38**:223–234.

Addis, G., Kefyalew, A. & Zewdu, W. 2014. Phenotypic Characterization of Indigenous Chicken Ecotypes in North Gondar Zone, Ethiopia. *Global Veterinaria*, **12(3**):361-368.

Addisu, H., Hailu, M. & Zewdu, W. 2013.Indigenous Chicken Production System and Breeding Practice in North Wollo, Amhara Region, Ethiopia. *Poult Fish Wildl Sci*., **1**:108.

Addisu, H., Zewdu, W. & Hailu, M. 2014. Breeding Practices and Objectives of Indigenous Chicken in North Wollo Amhara Regional State, Ethiopia. *International Journal of livestock production*, **5(1**):55-22.

Addisu, H. 2012. Phenotypic Characterization of Indigenous Chicken Ecotypes in North Wollo, Amhara Regional State, Ethiopia. M.Sc. Thesis submitted to the school of graduate of Bahirdar University, Bahirdar, Ethiopia.

Adedibu, I.I., Ayorinde, K.L. & Musa, A.A. 2014.Multifactorial Analysis of Morphological Traits of Extensively Reared Helmeted Guinea Fowls Numidia Meleagris in Kaduna and Katsina States of Nigeria .*British Journal of Applied Sciences and Technology* **4(25):**3644-3657.

Adekoya, K.O., Oboh, B.O, Adefenwa, M.A. & Ogunkanmi, L.A. 2013. Morphological Characterization of Five Nigerian Chicken Types. *Journal of Sci.Res.Dev*., **14**: 55-66.

Aklilu, A.H. 2007. Village Poultry in Ethiopia. Socio-Technical Analysis and Learning with Farmers. Published PhD Thesis, Wageningen University, Wageningen, the Netherlands.

Alabi, O.J., Ng'ambi, J.W., Norris, D. & Egena, S.S. 2012. Comparative Study of Three Indigenous Chicken Breeds of South Africa: Body Weight and Linear Body Measurements. *Agriculture Journal*, **7(3**):220-225.

Al-Atiyat, R. 2009**.** Diversity of Chicken Populations in Jordan Determined using Discriminant Analysis of Performance Traits. *International of Journal of Agriculture and Biology:* 1814-9596.

Alders RG, Pym RAE. 2009. Village Poultry: Still Important to Millions, Eight Thousand Years after Domestication. *World Poultry Sci J*. **65**:181–190.

Alem, A.T., Yayneshet, G.T & Aklilu, A.H. 2014. Socio-Economic Characteristics of Poultry Production in Lowland and Midland Agro-Ecological Zones of Central Tigray, Ethiopia. *International Journal of Livestock Production*, **5 (4**):71-80.

Alemu, Y. & Tadelle, D. 1997. The Status of Poultry Research and Development in Ethiopia, Research Bulletin No.4, Poultry Commodity Research Program Debrezeit Agricultural Research Center. Alemaya University of Agriculture, Ethiopia. pp. 62.

Alewi, M., Melesse, A. & Teklegiorgis, Y. 2012. Crossbreeding Effect on Egg Quality Traits of Local Chickens and Their F 1 Crosses With Rhode Island Red and Fayoumi Chicken Breeds Under Farmers ' Management Conditions. *Journal of Animal Production Advances*, ***2*(8):** 697–705.

Alexander, D.J .2001. Newcastle Disease. *British Poultry Science*, **42(1**):5-2.

Al-Qamashoui, B., Mahgoub, O., Kodim, I. & Schlecht, E. 2014. Towards Conservation of Omani Local Chicken: Phenotypic Characteristics, Management Practices and Performance Traits .*Asian Australas.J.Anim.Sci*., **27 (6):**767-777.

Amsalu, A. 2003. Practical Poultry Training Manual (Unpublished). Amhara Region Agricultural Research Institute, Kombolcha Poultry Research and Multiplication Center.

Apuno, A.A., Mbap, S.T. & Ibrahim, T. 2011.Characterization of Local Chickens (Gallus Gallus Domesticus) in Shelleng and Song Local Government Areas of Adamawa State, Nigeria .Agriculture and Biology Journal of North America,**2(1**):6-14.

Armstrong, J.B. 2006. Inbreeding: why we will not do it? http://www.parispoodles.com/inbreeding.html.

Ayalew, M. & Adane, T. 2013. Evaluation of Indigenous Chicken Productivity by Using a Questioner Survey, in Selected Chagni Town, Awi - Administrative Zone, Amhara Region, Ethiopia. *World Science Research Journal*, 1(February), 26–35.

Berthouly-Salazar, C., Rognon, X., Van, T.N., Gély M., Chi, C.V., Tixier-Boichard M., Bed'Hom, B., Bruneau, N., Verrier, E., Maillard, J. C. and Michaux, J.R. 2010. Vietnamese Chickens: A Gate towards Asian Genetic Diversity. *BMC Genetics*, **11**: 53.

Billah, S. M., Nargis, F., Hossain, M. E., Howlider, M. A. R. & Lee, S. H. 2013. Family Poultry Production and Consumption Patterns in Selected Households of Bangladesh. *Journal of Agricultural Extension and Rural Development*, **5(4)**: 62-69.

Bogale, K. 2008. In Situ Characterization of Local Chicken Eco-Type for Functional Traits and Production System in Fogera Woreda, Amhara Regional State.Msc.Thesis Submitted to the School of Graduate of Haramaya University, Haramaya, Ethiopia.

Botswana Network of People Living with HIV and AIDS .2010. Annual Technical Report - October 2009 to September 2010: Village Chicken Component. Gaborone, Botswana.

Ceballos, P., Molina, J., Franco, A. & Palacios, B. 1989. Manual Del Anillador. pp. 94–113 (ICONA – MAPA), (Madrid)

Cervantes, I., Goyache, F., Molina, A., Valera, M. & Gutierrez, J. P. 2008. Application of Individual Increase in Inbreeding to Estimate Realized Effective Sizes From Real Pedigrees. *Journal of Animal Breeding and Genetics* **125**: 301–310.

Cochran, W. G. 1963. Sampling Techniques, 2nd Ed., New York: John Wiley and Sons, Inc.

Craig, R., Dick, D. & Christine, H. 2006. Traditional Breeding Programs for the Home Flock from the April/May, 2006 issue of backyard poultry.

Crawford, R. D. 1990**.** Poultry Breeding and Genetics. Elsevier, Amsterdam.

Crawford, R. D.1990. Origin and History of Poultry Species. In: Poultry Breeding and Genetics. Ed. By R. D. Crawford. Elsevier, Amsterdam.

Crawford, R.D.1984. Domestic Fowl. In Evolution of Domesticated Animals, ed.L.L.Mason, 298-311.London.

Cruz-Castillo, J.G., Ganeshanadam, S., Mackay, B. R., Lawes, G.S., Lawoko, C.R.O. & Woolley, D.J. 1994. Applications of Canonical Discriminant Analysis in Horticultural Research.*HortScienc*e, **29:**1115-1119.

CSA (Central Statistics Agency). 2009. Agricultural Sample Survey 2009/10. Report on Livestock and Livestock Characteristics, **2**. Statistical Bulletin No. 468. Addis Ababa, Ethiopia.

CSA. 2003. Statistical Report on Livestock and Farm Implements, part IV, Addis Ababa, Ethiopia.

CSA. 2011. Agricultural Sample Survey 2010/11. Statistical Bulletin 2: 505 Report on Livestock and Livestock Characteristics, Addis Ababa

CSA (Central Statistics Agency). 2013. Agricultural Sample Survey 2013/14. Report on Livestock and Livestock Characteristics, Volume II. Statistical Bulletin 573.Addis Ababa, Ethiopia.

Daikwo, I.S., Okpe, A.A. & Ocheja, J.O. 2011.Phenotypic Characterization of Local Chickens in Dekina.*International Journal of Poultry Science*, **10(6):**444-447.

Dancause, K. N., Vilar, M. G., Steffy, R. & Lum, J. K. . 2011. Characterizing Genetic Diversity of Contemporary Pacific Chickens Using Mitochondrial DNA Analyses. *PLoS ONE* **6(2):**e16843.

Darwin, C .1868. The Variation of Animals and Plants under Domestication. London, UK: John Murray.

Dawit, G. 2010. Market Chain Analysis of Poultry: The Case of Alamata and Atsbi-Wonberta Woredas of Tigray Region. A Thesis Submitted to the Department of Agricultural Economics, School of Graduate Studies of Haramaya University. Haramaya, Ethiopia.

Dolberg, F. 2003. Review of Household Poultry Production as a Tool in Poverty Reduction with Focus on Bangladesh and India. FAO Pro-Poor Livestock Policy Initiative Working Paper No. 6. Food and Agriculture Organizations of the United Nations. Rome.

Duguma, R .2006. Phenotypic Characterization of Some Indigenous Chicken Ecotypes of Ethiopia. *Livestock Research for Rural Development*. Volume 18, Article #131. Retrieved from http://www.lrrd.org/lrrd18/9/dugu18131.htm.

Duguma, R. 2009**.** Understanding the Role of Indigenous Chickens during the Long Walk to Food Security in Ethiopia. *Livestock Research for Rural Development. Volume 21, Article #116.* Retrieved from Http://Www.Lrrd.Org/Lrrd21/8/Dugu21116.Htm.

EEA (Ethiopia Economic Association).2002.Land Tenure and Agriculture Development in Ethiopia. Ethiopia Economic Policy Research Institute, Addis Ababa.

Egahi, J.O., Dim, N., Momoh, I. & Gwaza, D.S .2010. Variations in Qualitative Traits in the Nigerian Local Chicken. *International Journal of Poultry Science,* **9 (10**): 978-979.

Egena, S.S.A., Ijaiya, A.T., Ogah, D.M. & Aya, V.E. 2014. Principal Component Analysis of Body Measurements in a Population of Indigenous Nigerian Chickens Raised under Extensive Management System. *Slovak J. Anim.Sci.* , **47(2**): 77-82.

Emebet, M., Horpal, S., Tesefaye, S. & Anna, M. J. 2014. Phenotypic Characterization of Indigenous Chicken Populations in South West and South Part of Ethiopia. *British Journal of poultry Sciences*, 3**(1**): 15:19.

Emuron, N., Magala, H., Kyazze, F.B., Kugonza, D.R. & Kyarisiima, C.C. 2010.Factors Influencing the Trade of Local Chickens in Kampala City Markets. *Livestock Research for Rural development*, **22(4**).

Eriksson, J., Larson, G., Gunnarsson, U., Bedhom, B., Tixier-Boichard, M., *et al*. 2008. Identification of the Yellow Skin Color Gene Reveals a Hybrid Origin of the Domestic Chicken. *Plos Genet*, 4(2):E1000010.Doi:10.1371/Jorurnal.Pgen.1000010.

Eskinder, A., Grum, G., Kefelegn, K. & Tadelle, D. 2014. Quantititative Morphological Traits as a Measure of Genetic Diversity for Two Indigenous Chicken Ecotypes in Ethiopia .In: Proceedings, 10^{th} World Congress of Genetic Applied to Livestock Production.

Eskindir, A., Kefelegn, K., Tadelle, D. & Banerjee, A.K. 2013. Phenotypic Characterization of Indigenous Chicken Populations in Ethiopia .*International Journal of Interdisciplinary and Multidisciplinary Studies*, **1(1**):24-32.

Falasade, O.A. & Obinna, E. 2009. Effects of Genotype x Sex Interaction on Growth and Some Development Characteristics of Rose and Anak Broiler Strains in the High Rainforest Zone of Nigeria .*Asian Journal of Poultry Sciences*, 1-6.

Falconer, D.S. & Mackay, T.F.C., 1996. Introduction to Quantitative Genetics, (Longman Group, Essex, UK).

FAO (Food and Agriculture Organization of the United Nations). 2003. Egg Marketing –A Guide for the Production and Sales of Eggs .FAO Agricultural Services Bulletin 150, Rome.

FAO. 2009a. A Review of the Current Poultry Disease Control Strategies in Smallholder Poultry Production Systems and Local Poultry Populations in Uganda. Prepared by Terence Odoch Amoki, Clovice Kankya, Eunice L Kyomugisha, Denis K. Byarugaba, Nicoline de Haan and Karin Schwabenbauer. AHBL - Promoting strategies for prevention and control of HPAI. Rome.

FAO. 2009b. Good Practices in Small Scale Poultry Production: A manual for Trainers and Producers in East Africa. Rome.

FAO.2012a. GLOBAL POULTRY TRENDS 2012.Reterived from web site: http://www.thepoultrysite.com/articles/2515/global-poultry-trends-2012-poultry-increases-its-share-of-global-meat-production

FAO. 2012b. Phenotypic Characterization of Animal Genetic Resources.FAO Animal Production and Health Guidelines No. 11. Rome.

Faruque, S., Siddiquee, N.U., Afroz, M.A. & Islam, M.S. 2010. Phenotypic Characterization of Native Chicken Reared Under Intensive Management System. *Journal of Bangladesh Agricultural University,* **8(1)*:*** *79-82.*

Faustin, V., Adégbidi, V.F., Garnett, S.T., Koudandé, D.O., Agbo, V. & Zander, K.K. 2010. Peace, Health or Fortune? Preferences for Chicken Traits in Rural Benin.Ecol Econ, **69**:1848–1857.

Fisseha, M., Azage, T. & Tadelle, D. 2010. Indigenous Chicken Production and Marketing Systems in Ethiopia: Characteristics and Opportunities for Market-Oriented Development. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 24. Nairobi, Kenya, ILRI.

Fisseha,M .2009.Studies on Production and Marketing Systems of Local Chicken Ecotypes in Bure Woreda, North-West Amhara.A Thesis Submitted to the Department of Animal and Range Sciences of Hawassa College of Agriculture, School of Graduate Studies of Hawassa University, Awassa, Ethiopia.

Fisseha, M. & Tadelle, D. 2010**.** Characterization of Village Chicken and Egg Marketing Systems of Bure district, North-West Ethiopia. *Livestock Research for Rural Development. Volume 22, Article #196.* Retrieved November 29, 2014, from http://www.lrrd.org/lrrd22/10/moge22196.htm.

Francesch, A., Villalba, I. & Cartañà, M. 2011. Methodology for Morphological Characterization of Chicken and Its Application to Compare Penedesenca and Empordanesa Breeds. *Animal Genetic Resources,* **48**: 79–84.

Frankham, R., Bradshaw, C.J.A. & Brook, B.W. 2014. Genetics in Conservation Management: Revised Recommendations for the 50/500 Rules, Red List Criteria and Population Viability Analyses.*Biol.Conserv*., **170**:56-63.

Franklin, I.R.1980. Evolutionary Change in Small Populations. M.E.SouleandB.A.Wilcox (eds.), *Conservation Biology: An Evolutionary Ecological Perspective*. Sunderland, Mass.: SinauerAssociates. Pp 135-140.

Fumihito, A., Miyake, T, Sumi S, *et al*. 1994. One Subspecies of the Red Jungle Fowl (Gallus Gallus) Suffices as the Matriarchic Ancestor of All Domestic Breeds. Proceedings of the National Academy of Sciences of the USA 91, 12 505–9.

Fumihito, A., Miyake, T., Takada, M., Shingu, R., Endo. T., *et al*. 1996. Monophyletic Origin and Unique Dispersal Patterns of Domestic Fowls. Proceedings of the National Academy of Sciences of the USA, **93**: 6792–6795.

Gueye, E.F. 1998. Village Egg and Fowl Meat Production in Africa. *World Poultry Sci J*, **54**:73–86.

Gueye, E.F.2002. Employment and Income Generation through Family Poultry in Low-Income Food-Deficit Countries. *World Poultry Sci J.*, **58**:541–557.

Guni, F. S. & Katule, A. M. 2013. Characterization of Local Chickens in Selected Districts of the Southern Highlands of Tanzania: I. Qualitative Characters. *Livestock Research for Rural Development,* **25(9**).

Gwaza, D.S., Tor, E.T., Noah & I.Wamagi, T. 2013. Discriminant Analysis of Morphological Traits in Selected Population of the Tiv Local Chickens Ecotypes in the Derived Guinea Savannah of Nigeria .IOSR *Journal of Agriculture and Veterinary Science (IOSR-JAVS*), **3**: 60-64.

Hagan, J.K., Bosompem M. & Adjei, I.A. 2013.The Productive Performance of Local Chickens in Three Ecological Zones of Ghana. *ARPN Journal of Agriculture and Biological Science*, **8(1)**:51-56.

Hailemichael, N. 2013. On-farm Phenotypic Characterization of Indigenous Chicken and Chicken Production Systems in Southern Zone of Tigray, Northern Ethiopia. MSc. Thesis submitted to School of Graduate Studies of Haramaya University, Ethiopia.

Hailu, M. 2012**.** Review on Major Viral Diseases of Chickens Reported in Ethiopia. *Journal of Infectious Diseases and Immunity***, 4 (1):**1-9.

Hailu, M., Grimachew, S. & Mehammed, N. 2012. Challenges and Prospects of Village-Based Exotic Chicken Development Strategy in Amhara Regional State, Northwest Ethiopia .Global Journal of Science Frontier Research Agriculture and Veterinary Sciences.**12(1**):40-49.

Halima, H., 2007. Phenotypic and Genetic Characterization of Indigenous Chicken Populations in Northwest Ethiopia. PhD Thesis Submitted to the Faculty of Natural and Agricultural Sciences Department of Animal, Wildlife and Grassland Sciences University of the Free State, Bloemfontein, South Africa.

HARC (Humera Agricultural Research Center). 2013. Annual Report on land coverage of weredas in Western Zone of Tigray (Unpublished).

Harun, M., Cambaza, A., Alemao, L., Maxhuza, G., Joaquim, M., Macanza, G., Namaneque, A., Lobo, O. & Alders, R. 2001. Community Based Experiences in Controlling Newcastle Disease in Rural Areas of Mozambique to Achieve Food Security, Poverty Alleviation and HIV/AIDS Mitigation. Mozambique. AusAID Southern Africa Newcastle Disease Control Project (SANDCP).

Hassen, K., Dasash, O. H. & Achenef, M. 2012. Study on Status and Constraints of Village Poultry Production in Metema District, North-Western Ethiopia. *American-Eurasian Journal of Scientific Research,* **7 (6)**: 246-251.

Horst, p.1989.Native Fowls as a Reservoir of Genomes and Major Genes with Direct and Indirect Effect on the Adaptability and Their Potential for Tropically Oriented Breeding Plans.Arch.Geflugelk, **53(3**):93-101.

Humphreys, M.O. 1991. A Genetic Approach to the Multivariate Differentiation of Perennial Ryegrass (Lolium PerenneL.) Cultivars. *Heredity* .**66**:437-443.

Hunduma, D., Regassa, C., Fufa, D., Endale, B. & Samson, L. 2010. Major Constraints and Health Management of Village Poultry Production in Rift Valley of Oromia, Ethiopia. *American-Eurasian J. Agric. Environ.Sci*., **9(5):** 529-533.

Jabbar, M.A., Swallow, B.M., d'Ieteren, G.D.M. & Busari, A.A. 1998. Farmer Preferences and Market Values of Cattle Breed of West and Central Africa. *Journal of Sustainable Agriculture*, **12**: 21–47.

Johann, S.r, Maria, W. & Zewdu, W. 2009. First progress report on genetic and phenotypic characterization and designing of breeding strategy for an indigenous cattle breed in north western Ethiopia: A contribution for sustainable genetic resources utilization, Vienna, Australia.

Kanginakudru, S., Metta, M., Jakati, R. D. & Nagaraju, J. 2008. Genetic Evidence from Indian Red Jungle Fowl Corroborates Multiple Domestication of Modern Day Chicken. *BMC Evol.Biol*., **8**:174.

Kathy, S.M. 2012. Water is Critically Important to Chickens. Retrieved from https://www.google.com/#q=water+is+critically+important+to+chickens++by+mormino+2012.

Kefyalew, A.2013.Review on Threats, Attempts and Opportunities of Conserving Indigenous Animal Genetic Resources in Ethiopia. *African Journal of Agricultural Research*, **8(23**):2806-2813.

Kgwatalala, P. M., Nogayagae, M., & Nsoso, S. J. 2012. Growth Performance of Different Strains of Indigenous Tswana Chickens under Intensive Management System. *African Journal of Agricultural Research*, **7(16):** 2438–2445.

Kingor, A.M., Wachira, A.M. & Tuitock, J.K.2010.Indigenous Chicken Production in Kenya: A Review. *International Journal of Poultry Sciences*, **9(4**):309-316.

Kingori, A.M. 2011. Review of the Factors that Influence Egg Quality and Hatchability in Poultry. International Journal of poultry science, **10(6):**483-492.

Kosgey, I .S. 2004. Breeding objectives and breeding strategies for small ruminants in the Tropics. Ph.D. Thesis, Wageningen University, The Netherlands.

Krueger, R. A., & Casey, M. A. 2000. Focus groups: A Practical Guide for Applied Research (3rd edition.) Thousand Oaks, Calif.: Sage.

Lakhotia, R. L. 2003. Poultry Eggs. Agrobios. Jodhpur (India). Pp.1-9, 13-25.

Liu, Y. P., G. S. Wu, Y. G. Yao, Y. W. Miao, G. Luikart, M. Baig, A. Beja-Pereira, Z. L. Ding, M.G. Palanichamy and Y. P. Zhang.2006. Multiple Maternal Origins of Chickens: out of the Asian Jungles. *Mol. Phylogenet. Evol*. , **38:**112-119.

Lwelamira, J., Kifaro, G. C. & Gwakisa, P. 2008**.** Breeding strategies for improving performance of Kuchi chicken ecotype of Tanzania for production under village conditions. *Volume 20, Article #171.*Retrieved November 28, 2014, from http://www.lrrd.org/lrrd20/11/lwel20171.htm

Maiwashe, A., Nephawe, K. A., van der, Westhuizen, R. R., Mostert, B. E. & Theron, H **.**E. 2006 .Rate of inbreeding and effective population size in four major South African dairy cattle breeds. *South African Journal of Animal Science,* **36**: 50–57.

Mammo, M. 2006. Survey on Village Chicken Production under Traditional Management Systems in Jamma Woredas, South Wollo, Ethiopia. M.Sc. Thesis Presented to School of Graduate Studies of Alemaya University, Ethiopia.

Mandisa, B.A.M. 2012**.** Morphometric Characteristics and Consumer Acceptability of Meat from Potchefstroom Koekoek, Black Australorp Venda and Ovambo Chickens.A Dissertation Submitted to the Discipline of Animal and poultry science school of Agriculture, Earth and Environmental sciences college of Agriculture, Engineering and science university of Kwazalu-Natal Pietermaritzburg, South Africa.

Matiwos, H., Negassi, A.., & Solomon, D. 2013. Production Performance of Local and Exotic Breeds of Chicken at Rural Household Level in Nole Kabba Woreda, Western Wollega, Ethiopia. *African Journal of Agricultural Research,* **8(11):** 1014–1021.

Mekonnen, G. 2007. Characterization of Smallholder Poultry Production and Marketing System of Dale, Wonsho and Loka Abaya Weredas of Southern Ethiopia. Msc. Thesis presented to the School of Graduate Studies of Hawassa University Hawassa Ethiopia.

Mekonnen, H., Kalayou, S., Kyule, M., Asfaha, M., & Belihu, K. 2011. Effect of Brucella Infection on Reproduction Conditions of Female Breeding Cattle and Its Public Health Significance in Western Tigray, Northern Ethiopia. *Veterinary medicine international*. 354943. doi:10.4061/2011/354943.

Melkamu, B. & Wube, A. 2013. Constraints and Opportunities of Village Chicken Production in Debsan Tikara Kebele at Gonder Zuria Woreda, North Gonder, Ethiopia. *International Journal of Scientific and Research Publication,* **3**.

Mengesha, M., Tamir, B. & Tadelle, D. 2008. Socio-Economical Contribution and Labor Allocation for Village Chicken Production in Jamma District, South Wollo, Ethiopia. *Journal of Livestock Resource Rural Development,* **20.**

Mengesha, M., Tamir, B. & Tadelle, D. 2011. Village Chicken Constraints and Traditional Management Practices in Jamma District, South Wollo, Ethiopia. *Livestock Research for Rural Development.* Volume 23, Article #37. Retrieved from http://www.lrrd.org/lrrd23/2/meng23037.htm.

Meseret, M., Solomon, D. & Tadelle, D .2011**.** Marketing System, Socio Economic Role and Intra Household Dynamics of Indigenous Chicken in Gomma Wereda, Jimma Zone, Ethiopia. *Livestock Research for Rural Development. Volume 23, Article #131.* Retrieved from http://www.lrrd.org/lrrd23/6/mese23131.htm.

Meseret, M. 2010.Characterization of Village Poultry Production and Marketing System in Gomma Wereda, Jimma Zone, Ethiopia.MSc.Thesis submitted to the school of graduate of Jimma University, Jimma, Ethiopia.

Moges, F., Abera, M. & Tadelle, D. 2010. Assessment of Village Chicken Production System and Evaluation of the Productive and Reproductive Performance of Local Chicken Ecotype in Bure District, North West Ethiopia. *Afr. J. Agric. Res*., 5**(13**):1739-1748.

Muchadeyi, F. C., Eding, H., Simianer, H., Wollny, C. B. A., Groeneveld, E. & Weigend, S. 2008. Mitochondrial DNA D-Loop Sequences Suggest a Southeast Asian and Indian Origin of Zimbabwean Village Chickens. *Anim. Genet*. **39**:615-622.

NAMP (North American Meat Processors Association). 2007.THE BUYERS' GUIDE of Beef,Lamb,Veal ,Pork and Poultry.John Wiley & Sons,Inc,Hoboken,New Jersey ,Canada.PP.215-262.

Narushin, V. G., Romanov, M. N., & Bogatyr, V. P. 2002. Relationship between Pre-Incubation Egg Parameters and Chick Weight after Hatching in Layer Breeds. *Biosystems Engineering*, **83(3):** 373–381.

Nassim, M., Do Duc, L., Phamkim, D., Frederic, F., Vu Dinh, T., Dang, V. B.h., Pascal, L. & Nicolas, A. M.2011.The Richicken Breed and Livelihood in North Vietnam: Characteristization and Prospects. *Journal of Agriculture and Rural Development in the Tropics and Sub Tropics,* **112(1**):57-69.

Nebiyu, Y., Brhan, T. & Kelay, B .2013. Characterization of Village Chicken Production Performance under Scavenging System in Halaba District of Southern Ethiopia.*Ethiop.Vet.J*., **17 (1**):69-80.

Nigussie, D., Tadelle, D., Liesbeth, H., van der, W., Johan, A.M. & van, A 2010a**.** Morphological Features of Indigenous Chicken Populations of Ethiopia. *Animal Genetic Resources*. Food and Agriculture Organization of the United Nations, **46:** 11-23.

Nigussie, D., Tadelle, D., Liesbeth, H., van der, W., Johan, A.M. & van, A. 2010b. Production objectives and trait preferences of village poultry producers of Ethiopia: implications for designing breeding schemes utilizing indigenous chicken genetic resources .*Trop Anim Health prod*., **42**:1519-1529.

Nigussie, D. 2011. Breeding Programs for Indigenous Chicken in Ethiopia: Analysis of Diversity in Production Systems and Chicken Populations PhD Thesis, Wageningen University, the Netherlands.

Nigussie, D. & Ogle, B. 2000. On Farm Evaluation of the Performance of RIR and Local Breeds of Chicken 8th ESAP Proceeding, August 21- 23 Addis Ababa, Ethiopia.

Nkululeko, J.N.2013.Prudent Poultry Farming as a Source of Livelihood and Food Security in a Changing Climate: The Case of Zhombe Communal Lands, Zimbabwe .*International Journal of Scientific and Research Publications,* **3(10**).

Nyoni, N. M. B. & Masika, P.J. 2012. Village Chicken Production Practices in the Amatola Basin of the Eastern Cape Province, South Africa. *African Journal of Agricultural Research* Vol. 7(17), pp. 2647-2652. Available online at http://www.academicjournals.org/AJAR DOI: 10.5897/AJAR11.1689 ISSN 1991-637X ©2012 Academic Journals

Ogah, D.M.2013. Canonical Discriminant Analysis of Morphometric Traits in Nigerian Indigenous Chicken Genotypes.*Trakina Journal of Sciences*, **2**: 170-174.

Ogah, D.M., Momoh, O.M. & Dim, N.I.2011. Application of Canonical Discriminant Analysis for Assessment of Genetic Variation in Muscovy Duck Ecotypes in Nigeria. Egypt. *Poult.Sci.,* **31(II**) :(429-436).

Okeno, T.O., Kahi, A.K. & Peters, J.K. 2010. Characterization of Indigenous Chicken Production Systems in Kenya: Household Flock Structure Dynamics and Breeding Practices. Proceedings of the 12th KARI Biennial Scientific Conferences, Kenya Agricultural Research Institute.

Panda, P.C., 1996.Textbook of Egg and Poultry Technology. Ram Printograph, Delhi, India.

Paolo, P. & Abebe, W. 2008. Review of the new features of the Ethiopian poultry sector Biosecurity implications. Food and Agriculture Organizations of the United Nations.Pp3-4.

Parmar, S. N. S., Thakur, M. S., Tomar, S. S. and Pillai, P. V. A. 2006. Evaluation of egg quality traits in indigenous Kadaknath breed of poultry. *Livestock Research for Rural Development*. 18 (9). Available at: http://www.lrrd.org/lrrd18/9/ parm18132.htm.

Permin, A. & Pedersen, G. 2000. Problems related to poultry production at Village level. Possibilities. Proc. of smallholder poultry projects in Eastern and Southern Africa, 22-25; May 2000, Morogoro, Tanzania.

Petrus, N. P .2011**.** Characterisation and Production Performance of Indigenous Chickens in Northern Namibia Regions. PhD Dissertation, University of Namibia.

Pettingill, O.S. Jr. 1985. Ornithology in laboratory and field. Burgess, Minneapolis, Minnesota, USA, Academic Press Inc. pp. 378–380.

Pinto, L.F.B., Packer, I.U., Demelo, C.M.R., Ledur, M.C. & Coutinho, L.L.2006. Principal Component Analysis Applied to Performance and Carcass Traits in The Chicken.*Anim.Res*., **55:**419-425.

Regassa, S. L., Bekana, E., & Geleta, T. 2013. Production Performance of Fayoumi Chicken Breed Under Backyard Management Condition in Mid Rift Valley of Ethiopia. *Herald Journal of Agriculture and Food Science Research*, **2(1**): 78–81.

Raji, A.O., Aliyu, J., Igwebuike, J.U. & Chiroma, S. 2009. Effect of Storage Methods and Time on Egg Quality Traits of Laying Hens in a Hot Dry Climate.*ARPN Journal of Agricultural and Biological Science* , **4(4**):1-7.

Romanov, M. N. & Weigend, S. 2001. Analysis of Genetic Relationship between Various Populations of Domestic and Jungle fowl using Microsatellite Marker. *Poult. Sci*., **80**:1057-1063.

Rosario, M.F., Silva, M., Coelho, A.A. D., Savino, V.J.M. & Dias, C.T.S. 2008.Canonical Discriminant Analysis Applied to Broiler Chickens Performance.*Animal*.**2**:419-429.

Rulz, J., Lunam, C., Groves, P.J. & Glatz. 2001. Effect of Storage Temperature and Duration on Hatchability. *Proc. Aust.Poult.Sci.Sym*.13.

RSHD (Rural Self-Help Development Agency). 2011. The study on socio-economic status of village Chickens at Ha Molemane (Berea), Phamong (Mohales' Hoek), Tebang, Ha Notsi, and Ribaneng (Mafeteng) of Lesotho. Maseru, Lesotho. pp.111.

Samson, L. & Endalew, B. 2010. Survey on Village Chicken Production and Utilization System in Mid Rift Valley Of Oromia, Ethiopia. *Global Veterinaria*, **5(4**):198-203.

SAS. 2008. Statistical Analysis System. Version 9.2, SAS Institute Inc., Cary, NC., USA.

Selam, M. & Kelay, B. 2013. Causes of Village Chicken Mortality and Interventions by Farmers in Ada'a District, Ethiopia. *International Journal of livestock production*, **4(6**):88-94.

Sheila, E.S. & Sara, S. 2007. Neb Guide on Causes, Control and Prevention of Cannibalistic Behavior Displayed by Poultry. University of Nebraska – Lincoln Extension, Institute of Agriculture and Natural Resources. Retrieved from http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=731.

Solomon, Z., Binyam, K., Bilatu, A. & Ferede, A.2013. Village Chicken Production Systems in Metekel Zone, Northwest Ethiopia. *Wudpecker Journal of Agricultural Research*, **2(9**):256-262.

Sonaiya, E.B. & Swan, S.E.J. 2004. Small-Scale Poultry Production. Food and Agriculture Organization of the United Nations (FAO). Animal Production and Health manual**;** Rome, 2004.

Sonaiya, E.B., 2000. Family Poultry and Food Security: Research Requirements in Science, Technology and Socioeconomics. Proceedings XXI Word's Poultry Congress, Montreal, Canada, August, 20-24.

Ssewannyana, E., Ssali, A., Kasadha, T., Dhikusooka, M., Kasoma, P., Kalema, J., Kwatotyo, B. A. & Aziku, L .2008. On-Farm Characterization of Indigenous Chickens in Uganda. *Journal of Animal & Plant Sciences,* **1(2**): 33 **–** 37.

Statistical Package for Social Sciences (SPSS). 2007. SPSS for windows. User's guide: Statistics version 16. Inc. Cary, NC.

Tadelle, D., Million, T., Alemu, Y. & Peter, K.J. 2003a. Village chicken production system in Ethiopia. 2. Use patterns and performance evaluation and chicken products and Socio economic function of chicken. *Livestock Research for Rural Development,* **15 (1).**

Tadelle, D .2003. Phenotypic and genetic characterization of chicken ecotypes in Ethiopia. Ph.D. Thesis, Humboldt University of Berlin, Germany.

Tadelle, D. 1996. Studies on village poultry production systems in the central high lands of Ethiopia, Msc Thesis, Swedish University of Agricultural Science, Uppsala.

Tadelle, D. & Ogle, B .2001. Village Poultry Production System in the Central High Lands of Ethiopia. *Tropical Animal Health and Production*, **33**: 521-537.

Tadelle, D., Million T., Alemu, Y. & Peters, K.J. 2003b.Village chicken production systems in Ethiopia: 1.Flock characteristics and performance*. Journal of Livestock Research Rural Development,* **15**.

Tadesse, D., Singh, H., Mengistu, A., Esatu, W. & Tadelle, D. 2013. Study on Management Practices and Marketing Systems of Village Chicken in East Shewa, Ethiopia. *AFRICAN JOURNAL OF AGRICULTURAL RESEARCH*, ***8*****(22**): 2696–2702.

Takeshi, H., Tetsuro, N. & Fumio, M.2004.Reduction of inbreeding in commercial females by rotational mating with several sire lines.Genet.Sel.Evol.36:509-526.

Teketel, F. 1986. Studies on the Meat Production Potentials of Some Local Strains of Chickens in Ethiopia. Ph.D. thesis presented to the University Giessen, Germany, pp123-126.

The Economist. 2011. FAO Statistics data Global-Livestock -counts. Retrived from web site: (http://www.economist.com/blogs/dailychart/2011/07/global-livestock-counts

Udeh, I. 2013. Prediction of Body Weight in Rabbits Using Principal Component Factor Scores in Multiple Linear Regression Model. *International Journal of the Bioflux Society Research Article*.

Udeh, I. & Ogbu, C.C. 2011. Principal Component Analysis of Body Measurements in Three Strains of Broiler Chicken. *Science World Journal*, **6(2**).

Upton, M**.** 2004.The Role of Livestock in Economic Development and Poverty Reduction [Online].Rome[Italy].FAO.<http://www.fao.org/ag/againfo/projects/en/pplpi/docarc/wp10.pd.

Weigend, S. & Romanov, M.N. 2001. Current Strategies for the Assessment and Evaluation of Genetic Diversity in Chicken Resources. *World Poult. Sci. J*., **57**: 275–287.

West, B. & Zhou, B-X .1988. Did chickens go north? New Evidence for Domestication. *Journal of Archaeological Science*, **15 (5**): 515-533.

Wolfová, M., Wolf, J., Pribyl, J., Zahradkova, R. & Kica, J. 2005. Breeding Objectives for Beef Cattle Used in Different Production Systems: 1. Model development. *Livestock Production Science*, **95**: 201–215.

Wondu, M., Mehiret, M. & Berhan, T.2013. Characterization of Urban Poultry Production System in Northern Gondar, Amhara Regional State, Ethiopia. *AGRICULTURE AND BIOLOGY JOURNAL OF NORTH AMERICA* ISSN Print: 2151-7517, ISSN Online: 2151-7525,doi:10.5251/abjna.2013.4.3.192.198©2013,ScienceHuβ, http://www.scihub.org/ABJNA

Worku, Z., Melesse, A. & T/Giorgis, T. 2012. Assessment of Village chicken production system and the performance of local chicken population in West Amhara Region of Ethiopia. *Journal of Animal Production Advances*, **2 (4**):199-207.

Wright, S. 1931. Effective Population Size. Evolution in Mendelian populations. Genetics **16**: 97–159.

Wright, S. 1938. Size of Population and Breeding Structure In Relation to Evolution. Science **87**: 430–431.

Yakubu, A., Abimiku, H. K., Musa-Azara, I. S., Idahor, K. O. & Akinsola, O. M. 2013. Assessment of Flock Structure, Preference in Selection and Traits of Economic Importance for Domestic Turkey (*Meleagris Gallopavo*) Genetic Resources in Nasarawa State, Nigeria. *Livestock Research for Rural Development. Volume 25, Article #18.*Retrieved from http://www.lrrd.org/lrrd25/1/yaku25018.htm.

Yakubu, A. & Ayoade, J.A. 2009.Application of Principal Component Factors Analysis in Quantifying Size and Morphological Indices of Domestic Rabbits.*Int.J.Morphol*.,**27(4**):1013-1017.

Yakubu A., Kuje D. & Okpeku, M. 2009. Principal Components as Measures of Size and Shape in Nigerian Indigenous Chickens .*Thai Journal of Agricultural Science*, **42(3**):167-176.

Yakubu, A., Kaankuka, F.G. & Ugbo, S.B. 2011. Morphometric Traits of Muscovy Ducks from Two Agro-Ecological Zones of Nigeria .*TROPICULTURA*, **29(2**):121-124.

Yitbarek, M. B., & Zewudu, A. 2013. Performance Evaluation of Local Chicken at Enebsie Sar Midir Woreda, Eastern Gojjam, Ethiopia. *Unique Research Journal of agricultural Sciences*, **1(2**): 6–10.

Yousif, I.A. & Eltayeb, N. M. 2011. Performance of Sudanese Native Dwarf and Bare Neck Chicken Raised Under Improved Traditional Production System. *Agriculture AND Biology Journal of North America*, (2000), 860–866. doi:10.5251/abjna.2011.2.5.860.866.

7. APPENDICES

Appendix I: Survey Questionnaire for the Phenotypic Characterization of Local Ecotypes in Western Zone of Tigray, Ethiopia

Name of household ____ Wereda_______ Kebele _____
Enumerator's Name_________Date of interview__________
Agro ecology: **1**. Lowland **2**. Mid- altitude 3. Highland

Annex 1: House Hold Characteristics

1. Sex and age of the respondent 1.1.Male _______1. 2. Female________ 1.3. Age________
2. Major Occupation____
3. Educational level of the respondent
1). Illiterate 2). Read & write 3).1st –4th 4). 5th –8th 5). 9th-12th
4. Religion of the respondent
1. Muslim ____________ 2.Orthodox Christian_______________3.others____________
5. Marital status of the respondents: 1. Single, 2. Married, 3. Divorced, 4. Widow/widower

6. Landholding per household (ha)

S.No	Land use type	Own (ha)	Rent (ha)	Total (ha)
1	Cultivated land			
1.2	land for crop production			
1.2	Land for fodder production			
2	Uncultivated land			
2.1	Grazing land			
2.2	Forestry land			
	Total			

7. Family size of the household

Age category	Male	Female	Total
≤14 years			
15≤and ≤60 years			
>60 years			
Total			

8. Number of animals per family per each livestock species

Type of livestock	Number of animals per family				
	Cow/doe/ewe/hen/ mare/camel/Jennet/ mule/swine	Ox/ram/buck/cock/ mule/camel/swine/Stallion/Jack/	Heifers/ pullets	Cockerels Young male animals	Male calves/ Lamb/kid/
Cattle					
Goat					
Sheep					
Horse					
Mule					
Donkey					
Poultry					
Camel					
Swine					

9. Type of farming system: 1. Sole livestock production, 2. Sole crop production, 3. Mixed

10. The main crops produce in the area: 1st __________ 2 nd ___________ 3 rd ________4th ______

11.Grazing pattern (style of feeding): 1. free grazing, 2. zero grazing (stall feeding), 3. Mixed feeding (eg. Stall feeding during rainy season, zero grazing during dry season), 4. Others specify

Annex 2: Production System/ Chicken Husbandry Practices

1. Livestock ownership and division of labor of the family member in livestock husbandry

Type	Owner(proprietor)	Responsible member of the family		
		Men	women	Children(M or F)
Cattle				
small ruminant				
Equines				
Poultry/ chickens				
Swine				
Camel				

2. Labor allocation in Husbandry practices of poultry in the family in order to importance

Ownership	Women	men	Children	
			Male	female
2.1. Labor profile				
2.1.1. Shelter construction				
2.1.2. Providing feed and wetter				
2.1.3. cleaning chicken house				
2.1.4. Selling chicken				
2.1.5. Selling eggs				
2.1.6. Treatment(purchasing drugs,etc)				

2.2. Decision making				
2.2.1. Selling eggs				
2.2.2. Selling chickens				
2.2.3. Home consumption eggs				
2.2.4. Home consumption chicken				
2.2.5. purchase of drugs				
2.2.6. purchase of eggs				
2.2.7. Purchase of chicken				
2.2.8. Gifted				

3. Flock Structure and population per household

Chicken type	Indigenous breed	Exotic breed	Cross bred
Layers(hen)			
Cock			
Cockerels			
Pullets			
chicks			
Total			

4. What is the trend of your chicken population dynamics since the time you started to keep chickens? And why? 1. Increasing, 2. Decreasing, 3. Stable, 4. Unknown, 5. If others, specify

5. Does the number of birds in your chicken flock change with the season? 1 = yes 2 = no

6. Which months are chicken numbers highest? ___________________________________

7. Which months are chicken numbers lowest? ___________________________________

8. Flock Structure

Chicken types	Sex of the owner		No. of poultry		Total number	Sources of foundation stock	Sources of replacement stock
	Male	Female	M	F			
Chicks (**0-8Wks**)							
Pullets (**8-20Wk**)							
Cockerel(**8-20Wk**)							
Layer /breeding hen							
Breeder /cocks							

8.1. Where do you get the first source of foundation? : 1. Home breed, 2. Hatched, 3.Gifted, 4.Inherited, 5. Custody, 6. Purchase, 7. Given as loan from government 8. Others, specify

8.2. Sources of replacement stock: 1. Home breed, 2. Hatched, 3.Gifted, 4.Inherited, 5. Custody 6. Purchase, 7. Given as loan from government 8. Others, specify

9. Do you feel there is need to improve your poultry production? 1. Yes, 2.No

9.1. If yes, why? (Prioritize the opportunities):

1st __________ 2nd __________ 3rd ___________ 4^{th}____________

9.2. If no why? Write the barriers or problems and prioritize them: (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5th etc)

1. Land scarcity___ 2.capital scarcity ___3.technical information __ 4.feed shortage___
5. Marketing problem____ 6.Theft___ 7.diseases___ 8. Predators __9. Others specify

HOUSING

1. Do you have separate poultry house (other than family dwellings)? 1. Yes 2.No

2. If your answer to Q (1) is No, what is a problem in the construction of separate Poultry house? House (Prioritize them):1st _______ 2nd ____3rd _______ 4th _____________

3. If your answer to Q (1) is no, where does your birds stay at night?

1. In the kitchen, 2. Family dwelling (room inside the house), 3. Perch on trees,
4. Hand woven basket, 5. Bamboo cages, 6. I don't know where they rest,

4. Do you believe it is advantageous to construct separate poultry house? 1. Yes, 2.No

5. If your answer to question (4) is yes state the advantages of separate poultry house.

1. To protect predator, 2. To prevent disease transmission from wild birds as well as other neighbouring chickens, 3. To control mating, 4. Others specify

6. If they rest in basket or cage or in separate house, do you practice cleaning of poultry house?

1. Yes, 2.No

7. If your answer to Q (6) is yes, how frequently do you clean poultry house? (How many times/ week)

1. Once, 2.twice, 3. Three times, 4.four times 5. Five times 6. Six times 7. Seven times
8. I do not clean it, 9.others specify

8. If your answer for Q (3) is purposely made chicken houses, the house is made from

1. Mud of blocks, 2) Iron sheet roof & wood, 3. Stone, 4. Bamboo/grass with wood, 5. Others specify

FEEDING AND FEED RESOURCES

1. Types of chicken rearing system (chicken production system): 1. scavenging,
2. Scavenging with seasonal supplementation, 3. Intensive

2. Do you practice purposeful feeding of your chicken in addition to scavenging? 1. Yes, 2.No

3. Do you practice supplementary feeding of your chicken? 1. Yes, 2.No

4. Indicate the ingredients you use for poultry feeding using the following table

Specific name of Feed(supplement)	State briefly form of consumption at different age level (collective for all classes or separately)					feed Sources	Person who Feeds chicken
	Chick	Layer	Cockerel	pullet	cock		

NB: Source of feeds: - (A. Household, B. harvest, C.purchase, D.Donation/gift/, E.others)
Person who feeds chickens: - (A. son, B. daughter. woman and D.man)

5. If you provide concentrates/grains, where do you buy these feeds?

1. Commercial farms, 2. Feed mills, 3. I do not purchase, I use grains produced on own farm , 4.others (Specify)

6. If your answer to question 2 is yes, when do you usually offer the supplement?

1. In the morning before they go out for scavenging, **2**. In the evening after scavenging
3. In the afternoon while scavenging, **4**. Any time during day times
5. In both evening after scavenging, in the morning before they go out for scavenging and in the afternoon while scavenging, **6.** Others, specify

7. If your answer to Q (1) is yes, how frequent do you feed your birds/ day?
7.1. In the Morning: - 1. None, 2. Once, 3. Twice, 4.Thrice or more
7.2. In the Afternoon: - 1. None, 2. Once, 3. Twice, 4.Thrice or more
7.3. In the Evening: - 1. None, 2. Once, 3. Twice, 4.three times or more

8. If you give feed how do you feed your birds?
1. Put feed in containers, 2. Throw on the ground for collective feeding, 3. If others, specify

9. How do you give the extra feeds (way of supplement feeding)?
1. Separate to different classes, 2. Together for the whole groups (for group feeding)

10. What is the basis (reasons) of your giving supplements?
1. To increase egg yield, 2. To increase meat yield, 3. Broodiness (during incubation)
4. Age, 5. To maintain health, 6. If others, specify

11. Do you perceive (observe) improvement due to extra supplements?
1. Egg production, 2. Growth, 3. Improved Health status, 4. Other

12. Indicate seasonal extra feeding of your chicken using the following table. (At which Season do you offer more extra feed to your birds?) and why? (Use asterisks)

Class	Autumn	Spring	Winter	Summer
Layer(hen)				
Pullets				
Cocks				
Chicks				
Cockerels				

13. If you do not give feed, reasons for not giving supplementary feeding
1. Lack of awareness about feed, 2. Unavailability of feed and feed ingredients,
3. High cost of feed & feed ingredients,
4. Time shortage, 5. Lack of cash/credit service, 6. Others, specify

14. Do your birds scavenge? 1. Yes, 2. No

16. At which season poultry feed shortage is most critical? 1. Rainy season 2. Dry season

WATERING AND WATER RESOURCES

1. Do you give water to your birds? 1. Yes, 2. No (why) __________________________

2. If you give water for the chickens, where do you get the water from?
1. Rain water, 2. River, 3. Tap water, 4.pond, 5.well, 6. Other, specify

3. If you give water for the chickens, what type of container do you use to supply water?
1. Metal, 2. Stone, 3. Pieces of pot, 4.plastic, 5. Others specify

4. If you give water for the chickens, how frequent do you wash the container per week?
1. Once, 2. Twice, 3. Three, 4. Four times, 5. Five times, 6.six times, 7. Seven times, 8.None,

5. If you give water for your chickens, how frequent do you provide?
1. Once/day, 2. Twice/day, 3.Adlib, 5.others specify

6. Distance of the water resource(s) from your homestead

No	Source of water(tap, river,borehole,pond, well , rain water and etc)	How far source of water from homestead (1. <1km, 2.1-5km, 3.5-8km, 4.8-10km,5.>10km)

HEALTH AND DISEASE CONTROL

1. Do you experience serious disease outbreaks? 1. Yes, 2. No
2. If yes, describe the common diseases you have experienced in your flock in the table below:

Local Name of disease	Symptoms	Traditional treatment	Vulnerable chicken age	Season disease out break	Severity death(age)	Resistance(age) and sex

NB: under Vulnerable age group and sex (1. Chicks, 2. Pullets, 3. Cockerels, 4.hens (layers), 5. cocks) and sex (1. Male and 2. Female)
3. How do you recognize sick birds? ____________________
4. What do you do when birds are sick?
1. Treat them myself, 2. Call in veterinarian, 3. Call in development agents
4. Cull/kill them all immediately, 5. Slaughter them all immediately for home Consumption, 6. Sell them all immediately, 7. If others. Specify ____________
5. Do you control the free movement of chickens all the times? 1. Yes, 2. No
6. If yes, would you mention the reason?
1. To protect from predators attack, 2. To avoid risk of contagious diseases
3. To protect from mixing with the village flock
4. To protect birds from picking and destroying crops/ vegetables
7. Do you control the free movement of chickens at a time of disease outbreak? 1. Yes, 2. No
8. Do your chickens scavenge mixed with that of your neighbors? 1. Yes, 2. No
9. What do you do with dead birds______________________?
10. What do you think the source(s) infection of chickens? 1. Brought chicken, neighbouring household, 3.unknown

ACCESS TO VETERINARY SERVICES

1. Do you have access to veterinary services? 1. Yes, 2. No
2. Do you vaccinate your chickens? 1. Yes, 2. No
3. If yes, for which diseases do you vaccinate your chickens? ____________
4. If your response to Q (1) is yes, Please indicate the available veterinary services and distance from your residential area.

Type of veterinary service(government or private)	Distance (<1km, 1-5km, 5-8km, 8-10km, >10km

EXTENSION CONTACT AND SERVICES

1. Have you ever discussed your poultry production & related problems with extension agents?
1. Yes, 2.No

2. If yes, where do you meet the extension agents? At
1. Agent office, 2. Farm house, 3.Fortnightly meetings, 4. Co-operative meetings,
5. The demonstration station (FTC), 6. Others, specify__________________

3. If yes how frequently do you contact the agent (days in a month) ___________________

4. If No, state the reasons for not contacting the extension agent in terms of importance

5. Have you ever heard about improved poultry production practices? 1. Yes, 2.No

6. If yes, what is your major source of information on improved poultry production practices?
1. Extension agents, 2. Relatives, 3. Other farmers, 4. Newspaper, 5. Market
6. Radio, 7.Neighbors, 8. Television, 9. Co-operative leader, 10.Other specify

7. Have you ever been trained regarding agricultural production interventions? 1. Yes, 2. No

8. If yes, in which? : 1. Crop production _____ 2. Dairy production _______
3. Sheep production ______ 4. Goat production ______ 5. Poultry production ________

9. Do you get poultry production extension service? : 1. Yes, 2. No.

10. If yes, in what ways? : 1. Advisory, 2. Provision of improved chicks
3. Providing feed, 4. Veterinary (medicine, vaccine), 5. Complete package, 6. Others

MARKETING

1. Where do you sell most of the chicken product (eggs and live chicken)? In the
1. Same village, 2. Neighboring village, 3. Nearest market, 4. Woreda market

2. If you sell chicken product in each of the village place, please indicate the distance of each market place to your homestead.

S.No.	Name of market place where you sell your chicken product	Distance from your homestead (km) :(1. <1km, 2.1-5km, 3. 5-8km, 4.8-10km, 5.>10km)

3. What are the major determinant of market price of egg in your area and rank them?
1. Shell color____, 2. Size of egg______ 3. Yolk color______4. Others _______

4. Is there variation of market price of live bird in your locality? 1. Yes, 2. No

5. If yes, List major determinant of market price of live chickens in your locality and rank them?
1. Plumage color _____ (which color is the most preferable) _____
2. Comb type______ (which type is the most preferable________
3. Shank color______ (which color is the most preferable_______
4. Body weight _____ (which weight is the most preferable______
5. Sex ___________ (which sex is the most preferable____6. Others specify _____

6. Who is your regular client (buyer) of chicken product? ________________

1. Village collectors/neighbors (traders who come to the village), 2. Collector in the market, 3. Sell to consumers

7. What are the problems relating to chicken product marketing in your experience?

1. Unstable chicken price, 2. Poor sales (demand seasonality), 3. Lack of market place
4. Poor infrastructure (road, market), 5. Lack of information, 6. Others, specify___

8. Market flow of your live chicken (directly/indirectly to consumer) and eggs (directly/indirectly)

9. What are the traits affecting consumers' preferences in purchasing &/or selling chickens and rank them based on their importance: live weight (growth) _____sex____plumage color______Comb type_____, longevity ___, diseases resistant___, good mothering qualities__, number of eggs laid___color of eggs laid___, ability to live on its own(needs no housing, good scavenger), and others_________________

Annex 3: Breeding Practices

1 what type of mating system do you practice? 1. Control mating 2.uncontrolled mating system

2. Do you practice breeding? 1. Yes, 2. No

3. If your response to Q (2) is yes, which method of breeding do you use? 1. Importing exotic, 2. Improving indigenous

4. If your method of breeding is improving indigenous, what is your way of improving indigenous? 1. Cross breeding, 2. Line breeding

5. Do you select chicken for breeding and production? : 1. Yes, 2. No

6. If yes, in which sex do you practice selection? 1. Male, 2. Female, 3. Both

7. Do you practice mating system for genetic improvement? 1. Yes, 2. No

8. If your answer to Q (7) is yes, your way(s) of mate controlling is: 1. culling poor productive, 2. cull at early age, 3. retaining, 4. Preventing mate, 5. others specify

9. What is your culling practice of less productive chickens? 1. Slaughter, 2.sell, 3. Sell or consume eggs, 4. If others specify

10. Do you purposely cull your chickens at any time? 1. Yes 2. No

11. What factors determine which bird you will cull?

1. Poor productivity, 2.Old age, 3.Sickness, 4. Frequent broodiness, 5. Lack of broodiness, 6.Other, specify__________

12. For what purpose do you cull the chicken?

1. For consumption, 2.For sale, 3.For sacrifice, 4. Other specify_______

13. If you culled old age chickens at what age of the bird do you decide to cull it? _______

14. If sickness is your answer for Q (11), do you cull to?

1. Avoid expected disease outbreak, 2. When the bird is already sick

15. Selection criteria for breeding:

Character	Selected	If yes, your preference(describe or choice are given)
Plumage color	Yes ,No	Red, Netch, Tikur, Kikoma, Gebsima, Anbesima, others specify
Body weight	Yes, No	Heavy, Medium Small
Egg production	Yes ,No	
Broody behavior	Yes No	1. Frequent brooder, 2.slow brooder, 3.not brooder at all
Mothering ability	Yes, No	1. Good ability of sitting during hatching 2. Good feeder of the chickens after hatching 3. Good hatching history 4.Good protector from predator/aggressive weaning the bird
Comb type	Yes, No	Single, Double. others, specify

16. Specific considerations during selections of hens for brooding/incubation

1. Select hens with larger body size, 2. Select hens with ample plumage feather cover
3. Select on the basis of previous hatching, 4. Broodiness, 5. Other criteria

17. Do you have inbreeding concept? 1. Yes, 2. No

18. If your response to Q (17) is yes, what is your practice of inbreeding control?

Breeding objectives (rearing purposes), farmers' trait preferences and village chicken production constraints:

1. Have you reared chickens purposely? 1. Yes, 2. No

2. What are your breeding objectives of chickens(rearing purposes)

1. Egg production for consumption, 2.egg production for hatching, 3. Meat production for consumption, 4. Meat production for sale, 5. Egg production for sale, 6.1 and 2, 7.1and 3, 8.1,2 and 5, 9.1, 2and 3, 10.1,2,3,4 and 5, 11.others specify

3. What are your trait preferences of your chickens? And rank according to their degree of preferences(as 1^{st} , 2^{nd} , 3^{rd} , 4^{th} , 5^{th} , 6^{th} , 7^{th} , 8^{th} , 9^{th} and etc)________________

4. Do you have an interest in improving the traits that you perceived as qualities of your chickens? 1. Yes, 2. No.

5. If response to Q (4) is yes, write the traits that you want to be improved through breeding interventions and put them in ascending order of importance or traits you desired to be improved

1. Adaptation (eg. Diseases and parasites, scavenging vigor and stress resistances) ______

2. Growth (weight) _______**3**. Egg production ________ **4**. Plumage color__________

5. Comb type________ **6**. Reproduction/hatching _____ 7. Others specify__________

Annex 4: Incubation Practices

EGG STORAGE

1. Do you prepare laying place nest for the layer? 1. Yes, 2. No.
2. The laying nests: 1. Common for all layers, 2. Individual
3. Do you collect the laid eggs? : 1. Yes, 2. No, 3. as necessary

4. If yes, where do you store eggs until sale or incubation? : 1. Grain, 2. Clay pots, 3. Plastic materials

4. Cartoons, 5. Floor depression, 6. Others

5. Source storage materials: 1. Purchase, 2. freely available, 3. others

6. Egg for setting (hatching) and market are stored in: 1. same containers, 2. in different containers

INCUBATION,

1. Incubation of eggs, 1. Broody hens, 2. Artificial, 3, any other

2. Do you prepare place for the incubating hen? 1. Yes, 2. No.

3. How many times do you incubate eggs per year? ___________

4. Sources of eggs for incubation

1. Purchased from market, 2. Purchased from neighbor, 3. Laid at home, 4. Other

5. Do you incubate eggs purchased from market? 1. Yes, 2. No

6 Position of eggs at storage and in incubation: 1. Pointed end down wards,

2. Pointed end upwards 3. Position on inside, 4. Do not mind position

7. What do you use as egg setting/incubation/ bedding materials?

1. Clay pot & straw bedding, **2**. Clay pot only/without bedding

3. Teff straw, **4**. Wheat (barley) straw, 5.) Other (Specify) ___________

8. Do you select eggs at a time or before incubation? 1. Yes, 2. No

9. If yes to Q (10), state the criterion of selecting eggs for incubation

I____________II______________ III. ___________ IV. ___________

10. Do you select any specific color of eggs for incubation? 1. Yes, 2. No

11. If yes which color do you prefer? Brown, White, Others ________

12. When do you usually incubate eggs (indicate season of incubation)? ______________

13. Is there seasonal variability on hatchability? Yes No

14. If yes, at which season did you have the worst (lowest) hatchability? ______________

15. When do you achieve the best results (indicate season)? ______________________

16. State the major causes for failure of hatching in order of importance

1st _________ 2nd _________ 3rd___________4th___________

17. Do you use the mother hen in raising the chicks? (Yes, No)

18. Do you test eggs for fertility? 1. Yes, 2. No

19. If yes, how do you test and prepare eggs before incubation?

1. Visual examination through the sun light, 2. Eggs will be cleaned before incubation

3. Floating eggs in a bucketed filled with water, 4. Other (Specify)

20. Practices to avoid broody behavior and rank them accordingly you commonly practiced

1. Hanging the bird upside down, 2. Depriving of the birds from feed & water

3. Disturbing in the nest, 4. Moving to neighbors, 5. Others_________

H. HATCHABILITY

Average days /clutch	Incubated eggs /clutch	hatched chicks / clutch	wasted eggs /clutch	chicks survive to adult hood/clutch

Hatchability (%) = [Hatched eggs/total incubated eggs] x 100

1. What do you think about the trend of the clutch period as the age of the bird increases?

1. Increase, 2. Decrease, 3.No change

2. After which clutch period the hen is supposed to set eggs for hatching chicks________

Annex 5: Productive and Reproductive Performance

1. Productivity report/Reproductive characteristics using the following table

Approximate sexual maturity age(month)		Approximate slaughter Age		Egg laid /clutch/hen	Clutch No./hen /year	Egg yield/ year	Productive life span (years)		Weaning age (month)	Incubated eggs /set	Hatched chicks/ cutch
M	F	M	F				M	F			

2. Egg yield in different clutch number for breeding local hen (layers):

Weaned chicks /hen/clutch	
Number of chicks survived up to adulthood	
Egg yield at clutch number	
One	
Two	
Three	
Four	
Five	
>five	

Annex 6: Village Chicken Production Constraints and Opportunities

1. What are the critical poultry productions constraints and rank them according to their degree of severity? ____

2. What are the opportunities of village chicken production in your area especially local chicken production? ____

Annex 7: Adaptability Traits

A .Heat/temperature/ tolerance: Male (High, Medium &Low) & female (High, Medium &Low)
B. cold tolerance: male (High, Medium &Low) & female (High, Medium &Low)
C. Basic temperament: Male (Docile, moderately & wild) & female (Docile, moderately & wild
D. Disease and parasites tolerance: male (Resistant, vulnerable, medium and others &female (Resistant, vulnerable, medium and others)
E .Drought tolerance: Male (high, Medium& Low) &Female (high, Medium &low)
F. Predator resistant: male (1.flightiness/ability to escape predators. And Females (1, 2 &3) 2. Unable to escape predators, 3. Others specify
G. Stress tolerance: male (High, Medium& Low) and female (High, Medium& Low)
H. scavenging vigor: male (1. Excellent, 2. Very good, 3. Good, 4. Fair, 5.poor) And female (1, 2, 3, 4&5)

Appendix II: Qualitative and Quantitative Traits

Annex 8: Qualitative Traits: Sources (FAO, 2012b)

1. Age (Months) ______
2. Sex (M/F) 1.Male______2.Fimale____________________________
3. Feather characteristics: **A.** Feather morphology: 1.Normal, 2.Silky, 3.Frizzle 4. Others
B. Feather distribution: 1. Normal, 2. Necked Neck, 3. Feathered shanks & Feet
4. Muffs and bread, 5. Vultures hocks, 6. Others (specify)
C. Feather growth rate: 1. Fast feathering, 2. slow feathering
D. Plumage colour: 1. completely white, 2.Completly black, 3. completely red
4. Grayish/Gebsima, 5. Multicolor/Ambesma, 6. Black with white stripes /Teterma
7. Red brownish/Kokima, 8. White with red spots/Seran, 9. Others/Specify
E. Breast feather colour**:** 1. Black, 2. Red, 3. White, 4. others/specify
F. Neck feather colour:
1. Completely white, 2.Completly black, 3. Completely red, 4.Grayish/Gebsima
5. Multicolor/Ambesma, 6. Black with white stripes/Teterma
7. Red brownish/Kokima, 8. White with red spots /Seran, 9. Others/Specify
G. Back feather colour: 1. completely white, 2.Completly black, 3. completely red
4. Grayish/Gebsima, 5. Multicolor/Ambesma, 6. Black with white stripes /Teterma
7. Red brownish/Kokima, 8. White with red spots/Seran, 9. Others/Specify
4. Skin characteristics: A. Skin colour: 1. White, 2. Yellow, 3. red, 4. Pink, 5.others
B. Shank colour: 1. Yellow, 2. Black, 3. White, 4. Blue 5.Green, 6.green-blue
5. Shank feather: 1. Present__2.Absent______
6. Spur presence: 1. Present_ 2. Absent______
7. Comb type: 1. Rose, 2.Pea, 3.Watnut/strawberry, 4. Single, 5.Duplex/V-shape, Double
8. Ear lobe/presence: 1. Present, 2.Absent__
9. Ear lobe colour: 1. White, 2.Red, 3.Black, 4. White & red, 5. others, specify__

10. Body Shape: 1. Blocky, B. Triangular, C. Wedge
11. Head shape: 1. Plain/Ebab-ras, 2. Crest/Gutya, 3. others, specify ___
12. Comb size: 1. small, 2. Medium, 3. Large
13. Eye color: 1. Black, 2.orange, 3.brown, 4.Red, 5.others
14. Comb color: 1.red, 2.pale, 3.brown, 4.black, 5.other

Annex 9: Definition of Body Colors by Community

1. Keyih= Key = complete red
2. Tsada= Netch = complete white
3. Tselim = Tikur = complete black
4. Sigemmo = Gebesima = Grayish mixture
5. Anbessa = Anbesima = multicolor
6. Keyih Cheber = Key Teterma = red with white or black strips
7. Tsada Cheber = Netch Teterma = white with red or black strips
8. Tselim Cheber = Tikur Teterma = Black with white or red strips
9. Gurama = Seran = white with red spots
10. Kokah = Kokima = red brownish or color of Kok
11. Zagra = Zagrama = Color of Zagra

Annex 10: Methodologies for Quantitative traits as developed by FAO (2012b) and Francesch, A. *et al*. 2011)

Body length: (length between the tip of the rostrum maxillare (beak) and that of the cauda (tail, without feathers); the bird's body should be completely drawn throughout its length.

Skull length: Was measured as the distance between the occipital bone to the insertion of the beak into the skull (where the plumage starts).

Skull width: Measured at eyes level.

Comb length: Distance between the insertion of the comb in the beak and the end of the comb's lobe.

Comb width: Distance from the tip of the central spike until insertion of the comb in the skull. If the number of spikes is even, the highest must be chosen

Beak length: Length from the tip of the beak until insertion of the beak into the skull

Beak width: Measured from the insertion of the beak in the skull and perpendicular until the end of the inferior mandible.

Ear lobes length: Maximum length, keeping the head of the bird perpendicular to the neck. Person holding the bird should catch the bird's legs with one hand and with the other hand hold the neck on the middle height and with index finger keeping the bird's head perpendicular to the neck's line.

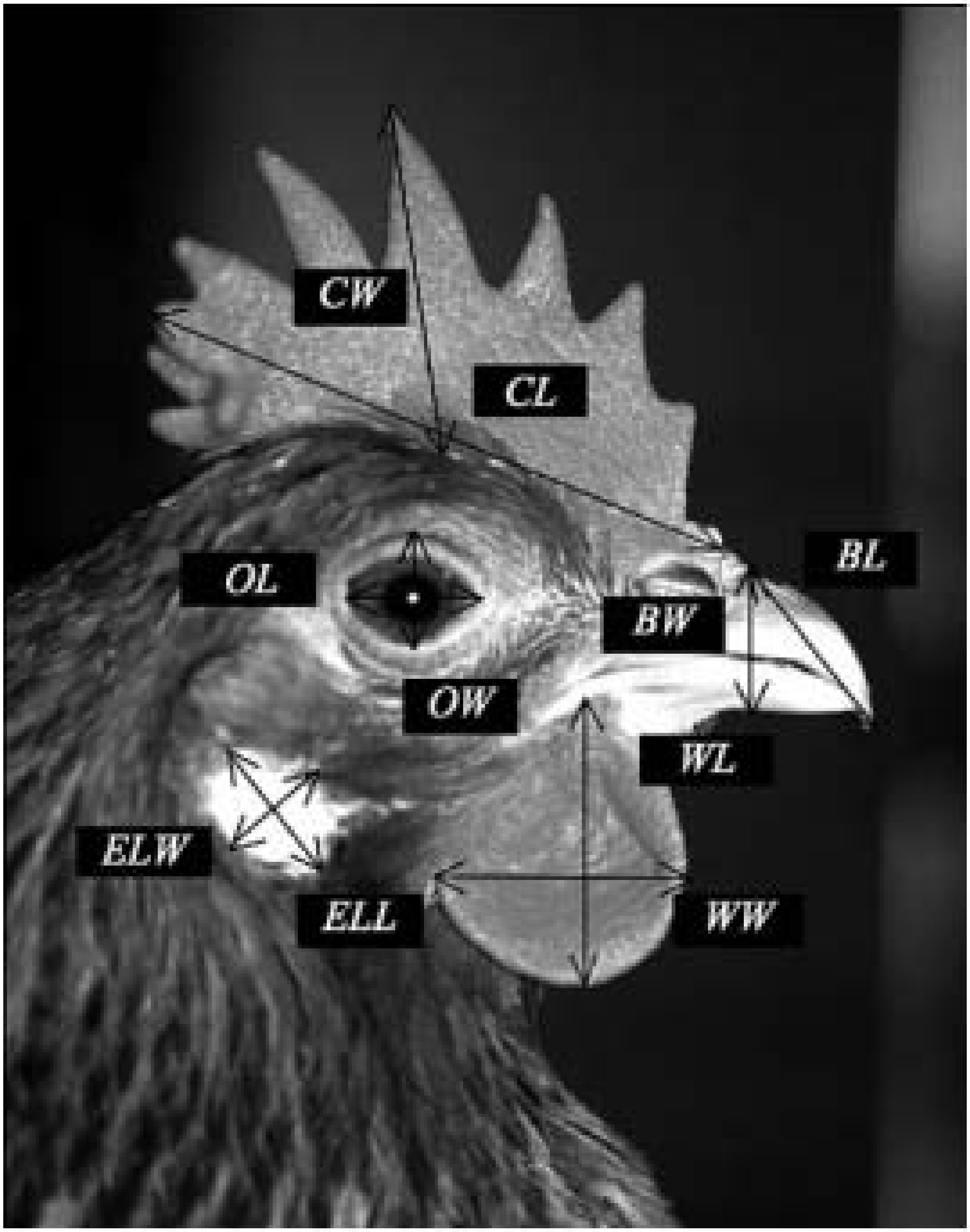
Ear lobes width: As in the previous measure measured the second-largest dimension.

Wattles length: Length from insertion of the right wattle into the beak, holding the wattle with one hand and drawing a straight line to the end of the wattle.

Wattles width: Measurement of the second maximum dimension of the wattle perpendicular to the length.

Neck length: The bird had to be immobilized on its left-hand side on the work table by an operator, stretching legs with one hand and the neck with the other hand, another operator measured the distance between the nape and the insertion of the neck into the body.

Wingspan: (Pettingill, 1985): Distance between the ends of the longest primaries with wings stretched. On the work table; maintain the joints of the wings as stretched as possible.



Appendix Figure 1: Measurement of head characteristics (**Francesch *et al*., 2011)**

Remark: CL=Comb length and CW=Comb width
WL=Wattle length and WW=Wattle width
ELL=Earlobe length and ELW= Earlobe width
BL=Beak length and BW=Beak Width

Appendix III: **List of Result Tables**

Appendix table 1: General livestock management responsibility of household family members in three agro-ecological zones of western Tigray

Livestock species	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Cattle					6.59(*)	0.037
Men	1(1.1)	1(0.8)	8(5)	10(2.6)		
Women	-	1(0.8)	5(3.1)	6(1.6)		
Men &women	12(12.8)	20(15.3)	13(8.1)	45(11.7)		
Men &male children	57(60.6)	86(65.6)	76(47.5)	219(56.9)		
Women & male children	9(9.6)	10(7.6)	19(11.9)	38(9.9)		
Men &female children	1(1.1)	3(2.3)	1(0.6)	5(1.3)		
Women and female children	1(1.1)	1(0.8)	1(0.6)	3(0.8)		
Men ,women &male children	-	1(0.8)	11(6.9)	12(3.1)		
Men , women & female children	-	-	1(0.6)	1(0.3)		
No cattle	13(13.8)	8(6.1)	25(15.6)	46(11.9)		
small ruminant					0.005(ns)	0.998
Men	1(1.1)	1(0.8)	8(5)	10(2.6)		
Women	1(1.1)	-	3(1.9)	4(1)		
Men &women	9(9.6)	20(15.3)	11(6.9)	40(10.4)		
Men &male children	49(52.1)	85(64.9)	73(45.6)	207(53.8)		
Women & male children	7(7.4)	12(9.2)	16(10)	35(9.1)		
Men &female children	1(1.1)	3(2.3)	1(0.6)	5(1.3)		
Women and female children	1(1.1)	1(0.8)	-	2(0.5)		
Men ,women &male children	-	-	1(0.6)	1(0.3)		
Men , women & female children	-	1(0.8)	1(0.6)	2(0.5)		
No small ruminant	25(26.6)	8(6.1)	46(28.7)	79(20.5)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed

Appendix table 1 (continued)

Livestock species	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Equines					5.541(ns)	0.063
Men	-	1(0.8)	3(1.9)	4(1)		
women	-	-	4(2.5)	4(1)		
Men &women	3(3.2)	16(12.2)	10(6.2	29(7.5)		
Men &male children	49(52.1)	73(55.7)	64(40)	186(48.3)		
Women & male children	6(6.4)	6(4.6)	4(2.5)	16(4.2)		
Men &female children	1(1.1)	2(1.5)	1(0.6)	4(1)		
women and female children	1(1.1)	1(0.8)	3(1.9)	5(1.3)		
Men ,women &male children	-	1(0.8)	23(14.4)	24(6.2)		
Men , women & female children	-	1(0.8)	1(0.6)	2(0.5)		
No equines	34(36.2)	30(22.9)	47(29.4)	111(28.8)		
Poultry					6.054(*)	0.048
women	41(43.6)	41(31.3)	70(43.8)	152(39.5)		
Men & women	-	1(0.8)	1(0.6)	2(0.5)		
Female children	-	-	1(0.6)	1(0.3)		
Women & female children	53(56.4)	87(66.4)	87(54.4)	227(59)		
Men & female children	-	2(1.5)	-	2(0.5)		
Men & male children	-	-	1(0.6)	1(0.3)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed

Appendix table 2: Households' problems in separate poultry house construction

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Problems in separate house construction					74.643(*)	0.000
Lack of awareness about poultry house	-	-	1(0.6)	1(0.3)		
Labor scarcity (1st) & to be protected from predators (2nd)	-	1(0.8)	-	1(0.3)		
Land scarcity	3(3.2)	-	3(1.9)	6(1.6)		
Land scarcity (1st),labor scarcity (2nd) & capital scarcity (3rd)	1(1.1)	-	1(0.6)	2(0.5)		
Land scarcity (1st) & capital scarcity (2nd)	3(3.2)	-	-	3(0.8)		
Labor scarcity (1st) & capital scarcity (2nd)	3(3.2)	7(5.3)	1(0.6)	11(2.9)		
Lack of awareness about poultry house (1st), capital scarcity (2nd) & weak extension support (3rd)	1(1.1)	4(3.1)	7(4.4)	12(3.1)		
Land scarcity (1st),weak extension (technical support (2nd) & Lack of awareness about poultry house (3rd)	-	1(0.8)	3(1.9)	4(1)		
Land scarcity (1st), capital scarcity (2nd), disease (3rd), predators (4th) &labor scarcity (5th)	-	-	3(1.9)	3(0.8)		
Lack of awareness about poultry house (1st), land scarcity (2nd), capital scarcity (3rd), labor scarcity (4th) & weak extension / technical support (5th)	-	-	3(1.9)	3(0.8)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed

Appendix table 2 (continued)

Variable	Agro- ecological zones				X^2-test	p-value
	Highlandn (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Lack of awareness about poultry house (1st), capital scarcity (2nd), labor scarcity (3rd) & weak extension support (4th)	-	1(0.8)	1(0.6)	2(0.5)		
Lack of awareness about poultry house (1st) &weak extension support (2nd)	19(20.2)	22(16.8)	25(15.6)	66(17.1)		
Land scarcity (1st), Lack of awareness about poultry house (2nd), capital scarcity (3rd)& weak extension support (4th)	-	1(0.8)	9(5.6)	10(2.6)		
Lack of awareness about poultry house (1st),weak extension support (2nd), capital scarcity (3rd), labor scarcity (4th) & fear of predators attack (snake) (5th)	1(1.1)	7(5.3)	2(1.2)	10(2.6)		
Fear of predators attack	3(3.2)	4(3.1)	-	7(1.8)		
Lack of awareness about poultry house (1st),weak extension support (2nd) & Fear of predators attack (3rd)	-		2(1.2)	2(0.5)		
Labor scarcity (1st), Lack of awareness about poultry house (2nd) & weak extension support (3rd)	5(5.3)	3(2.3)	1(0.6)	9(2.3)		
Fear of predators attack(1st), Labor scarcity (2nd), Lack of awareness about poultry house (3rd) & weak extension support (4th)	-	1(0.8)	-	1(0.3)		
Labor scarcity (1st), capital scarcity (2nd) & Fear of predators attack (3rd)	-	2(1.5)	-	2(0.5)		
Land scarcity (1st), capital scarcity (2nd) & labor scarcity (3rd)	1(1.1)	-	-	1(0.3)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n=number households interviewed

Appendix table 3: Households' Experiences with regard to poultry diseases

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Serious disease outbreak experience					0.569(ns)	0.752
Yes	93(98.9)	129(98.5)	159(99.4)	381(99)		
No	1(1.1)	2(1.5)	1(0.6)	4(1)		
Differentiation of sick birds					0.00(ns)	1.00
By observing symptoms	93(98.9)	129(98.5)	159(99.4)	381(99)		
Actions taken when the birds are sick					15.776(*)	0.000
Treat myself	64(68.1)	87(66.4)	135(84.4)	286(74.3)		
Call in veterinarians /development agent /	21(22.3)	31(23.7)	23(14.4)	75(19.5)		
Cull / kill them all immediately	1(1.1)	-	-	1(0.3)		
Slaughter them all immediately for home consumption	1(1.1)	1(0.8)	-	2(0.5)		
Nothing	6(6.4)	10(7.6)	1(0.6)	17(4.4)		
Managing dead birds					2.092(ns)	0.351
Throwing	89(94.7)	119(90.8)	143(89.4)	351(91.2)		
Burying	5(5.3)	12(9.2)	17(10.6)	34(8.8)		
Control practice of free movement of chickens all times					16.353(*)	0.00
yes	59(62.8)	63(48.1)	114(71.2)	236(61.3)		
No	35(37.2)	68(51.9)	46(28.8)	149(38.7)		
Reasons for controlling free movement of chickens all times					9.623(*)	0.008
To protect from predators attack	42(44.7)	44(33.6)	102(63.8)	188(48.8)		
To avoid risk of contagious disease	2(2.1)	-	-	2(0.5)		
To protect birds from picking & destroying crops & vegetables	5(5.3)	-	-	5(1.3)		
To protect from predators attack & avoid risk of contagious disease	-	-	5(3.1)	5(1.3)		

* ($p<0.05$) & ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Appendix table 3 (Continued)

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
To protect from predators attack & birds from picking & destroying crop & vegetables	10(10.6)	18(13.7)	1(0.6)	29(7.5)		
To avoid risk of contagious disease & protect birds from mixing with village flock	-	-	1(0.6)	1(0.3)		
To protect from predators attack & mixing with village flock	-	-	1(0.6)	1(0.3)		
To protect from predators attack ,avoid risk of contagious disease & protect from mixing with village flock	-	1(0.8)	4(2.5)	5(1.3)		
Control practice of free movement of chickens at time of disease outbreak					33.358(*)	0.00
Yes	4(4.3)	6(4.6)	39(24.4)	49(12.7)		
No	90(95.7)	125(95.4)	121(75.6)	336(87.3)		
Chickens scavenge mixed with neighbors					1.858(ns)	0.395
yes	88(93.6)	123(93.9)	144(90)	355(92.2)		
no	6(6.4)	8(6.1)	16(10)	30(7.8)		
Sources of chickens ‘ infection					4.301(ns)	0.116
chickens from market	19(20.2)	44(33.6)	38(23.8)	101(26.2)		
Chickens from neighbors	-	2(1.5)	9(5.6)	11(2.9)		
Chickens from both market & Neighbors	-	2(1.5)	7(4.4)	9(2.3)		
Contaminated feed (dead chicken body) & use the same water drinking containers with wild birds ,cats, dogs	1(1.1)	2(1.5)	1(0.6)	4(1)		
Fluctuations of temperature & coldness	-	1(0.8)	1(0.6)	2(0.5)		
chickens from market & contaminated feed	-	-	4(2.5)	4(1)		
Dirty poultry house & non-chemical spraying properly	-	1(0.8)	1(0.6)	2(0.5)		
Unknown	73(77.7)	77(58.8)	99(61.9)	249(64.7)		

* ($p<0.05$) & ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Appendix table 4: Access to veterinary services

Variable	Agro- ecological zones				X^2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Access to veterinary services					4.201(ns)	0.122
yes	87(92.6)	119(90.8)	136(85)	342(88.8)		
no	7(7.4)	12(9.2)	24(15)	43(12.2)		
Chicken vaccination practice					1.406(ns)	0.495
Yes	-	-	1(0.6)	1(0.3)		
No	94(100)	131(100)	159(99.4)	384(99.7)		
Distance of governmental veterinary service from homestead					123.505(*)	0.00
<1km	1(1.1)	1(0.8)	21(13.1)	23(6)		
1-5km	12(12.8)	24(18.3)	76(47.5)	112(29.1)		
5-8km	16(17)	29(22.1)	24(15)	69(17.9)		
8-10km	14(14.9)	20(15.3)	11(6.9)	45(11.7)		
>10km	42(44.7)	45(34.4)	1(0.6)	88(22.9)		
Distance of private veterinary service from homestead					5.113(ns)	0.078
<1km	-	-	3(1.9)	3(0.8)		
1-5km	2(2.1)	1(0.8)	3(1.9)	6(1.6)		
5-8km	-	2(1.5)	1(0.6)	3(0.8)		
8-10km	-	1(0.8)	-	1(0.3)		

* (p<0.05) & ns (p>0.05) and n=number of respondents interviewed per agro-ecology

Appendix table 5: Sources of information on improved poultry production practices and type extension services

Variable	Agro- ecological zones				X2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Have you heared about improved poultry production practices?					0.000(ns)	1.0
Yes	94(100)	131(100)	160(100)	385(100)		
No	-	-	-	-		
Major sources of information					12.827(*)	0.002
Extension agent	18(19.1)	45(34.4)	30(18.8)	93(24.2)		
Relatives	3(3.2)	-	1(0.6)	4(1)		
Farmers	2(2.1)	-	-	2(0.5)		
Radio	1(1.1)	-	-	1(0.3)		
Neighbors	1(1.1)	-	-	1(0.3)		
Extension agent and radio	-	34(26)	87(54.4)	121(31.4)		
Extension agent & farmers	68(72.3)	49(37.4)	1(0.6)	118(30.6)		
Extension agent, radio and neighbors	-	-	1(0.6)	1(0.3)		
Extension agent & relatives	-	-	27(16.9)	27(7)		
Extension agent, relatives & farmers	-	-	11(6.9)	11(2.9)		
Extension agent, relatives & television	-	-	2(1.2)	2(0.5)		
Extension agent, radio and television	1(1.1)	-	-	1(0.3)		
Extension agent, relatives & neighbors	-	2(1.5)	-	2(0.5)		
Extension agent, farmers & television	-	1(0.8)	-	1(0.3)		
Have you ever been trained regarding agricultural production intervention?					8.092(*)	0.017
Yes	63(67)	102(77.9)	107(66.9)	272(70.6)		
No	31(33)	29(22.1)	53(33.1)	113(29.4)		

* (p<0.05) & ns (p>0.05) and n=number of respondents interviewed per agro-ecology

Appendix table 5 (Continued)

Variable	Agro- ecological zones				X2-test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
If yes, in which?					13.443(*)	0.001
Crop production	15(16)	23(17.6)	12(7.5)	50(13.0)		
Dairy production	-	1(0.8)	-	1(0.3)		
Sheep production	-	1(0.8)	-	1(0.3)		
Poultry production	-	5(3.8)	-	5(1.3)		
Crop & poultry production	1(1.1)	3(2.3)	-	4(1)		
Dairy & crop productions	1(1.1)		-	1(0.3)		
Sheep, goat & poultry production	1(1.1)		-	1(0.3)		
Crop, dairy, sheep & goat production	36(38.3)	52(39.7)	76(47.5)	164(42.6)		
Crop, dairy, sheep, goat & poultry productions	9(9.6)	15(11.5)	4(2.5)	28(7.3)		
Crop, sheep & goat production	-	1(0.8)	1(0.8)	2(0.5)		
Sheep & goat production	-	1(0.8)	7(4.4)	8(2.1)		
None	31(33)	29(22.1)	53(33.1)	113(29.4)		
Do you get poultry production extension services?					3.556(ns)	0.169
Yes	93(98.9)	131(100)	156(97.5)	380(98.7)		
No	1(1.1)	-	4(2.5)	5(1.3)		
If yes, in what ways?					18.523(*)	000
Advisory	85(90.4)	106(80.9)	107(66.9)	298(77.4)		
Provision of improved chicks	-	-	3(1.9)	3(0.8)		
Advisory & Provision of improved chicks	8(8.5)	25(19.1)	43(26.9)	76(19.7)		
Provision of improved chicks & feed	-	-	1(0.6)	1(0.3)		
Advisory, Provision of improved chicks & feed	-	-	2(1.2)	2(0.5)		
None	1(1.1)	-	4(2.5)	5(1.3)		

* ($p<0.05$) & ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology

Appendix table 6: Sources of eggs for incubation, major causes of failure of hatching and time of best and worst hatchability

Variable	Agro- ecological zones				X2 -test	p-value
	Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)		
Season or time of incubation					13.41(*)	0.01
June – February	76(80.9)	125(95.4)	137(85.6)	338(87.8)		
June – January	-	1(0.8)	22(13.8)	23(6)		
June -September	-	-	1(0.6)	1(0.3)		
October – march	-	1(0.8)	-	1(0.3)		
June - march	-	4(3.1)	-	4(1)		
March – June	3(3.2)	-	-	3(0.8)		
October –may	15(16)	-	-	15(3.9)		
Is there seasonal variability on hatchability?					0.0(ns)	1.0
Yes	94(100)	131(100)	160(100	385(100)		
No	-	-	-	-		
Season /time of worst hatchability achievement					22.99(*)	0.00
March –may	76(80.9)	125(95.4)	153(95.6)	354(91.9)		
February –may	-	1(0.8)	7(4.4)	8(2.1)		
April –may	3(3.2)	5(3.8)	-	8(2.1)		
June –September	15(16)	-	-	15(3.9)		
Season /time of best hatchability attainment					13.365(*)	0.001
June – February especially autumn	76(80.9)	125(95.4)	139(86.9)	340(88.3)		
June – march	3(3.2)	4(3.1)	-	7(1.8)		
October - march	-	1(0.8)	1(0.6)	2(0.5)		
June – January	-	1(0.8)	20(12.5)	21(5.5)		
October – may	15(16)	-	-	15(3.9)		

* (p<0.05) & ns (p>0.05) and n=number of respondents interviewed per agro-ecology

Appendix table 7: Adaptive attributes of local chicken ecotypes

Chicken sex	Attributes	Agro- ecological zones			
		Highland n (%)	Midland n (%)	Lowland n (%)	Total n (%)
		Heat (temperature) tolerance of			
Male	High	-	-	160(100)	160(41.6)
&	Medium	-	131(100)	-	131(34.0)
Female	low	94(100)	-	-	94(24.4)
		Cold tolerance of			
Male	High	94(100)	-	-	94(24.4)
&	Medium	-	131(100)	-	131(34.0)
Female	low	-	-	160(100)	160(41.6)
		Basic temperament			
Male	Moderately	94(100)	131(100)	160(100)	385(100)
Female	Moderately	94(100)	131(100)	160(100)	385(100)
		Disease and parasites tolerance			
Male	Medium	94(100)	131(100)	160(100)	385(100)
Female	Medium	94(100)	131(100)	160(100)	385(100)
		Drought tolerance			
Male &	Relatively higher	-	-	160(100)	160(41.6)
Female	Relatively Medium	-	131(100)	-	131(34.0)
	Relatively lower	94(100)	-	-	94(24.4%)
		Predators resistant			
Male	Ability to escape predators	94(100)	131(100)	160(100)	385(100)
Female	Ability to escape predators	94(100)	131(100)	160(100)	385(100)
		Stress tolerance			
Male	Medium	94(100)	131(100)	160(100)	385(100)
Female	Medium	94(100)	131(100)	160(100)	385(100)
		Scavenging vigor			
Male &	Excellent	94(100)	131(100)	121(75.6)	346(89.9)
Female	Very good	-	-	39(24.4)	39(10.1)

* ($p<0.05$) & ns ($p>0.05$) and n=number of respondents interviewed per agro-ecology